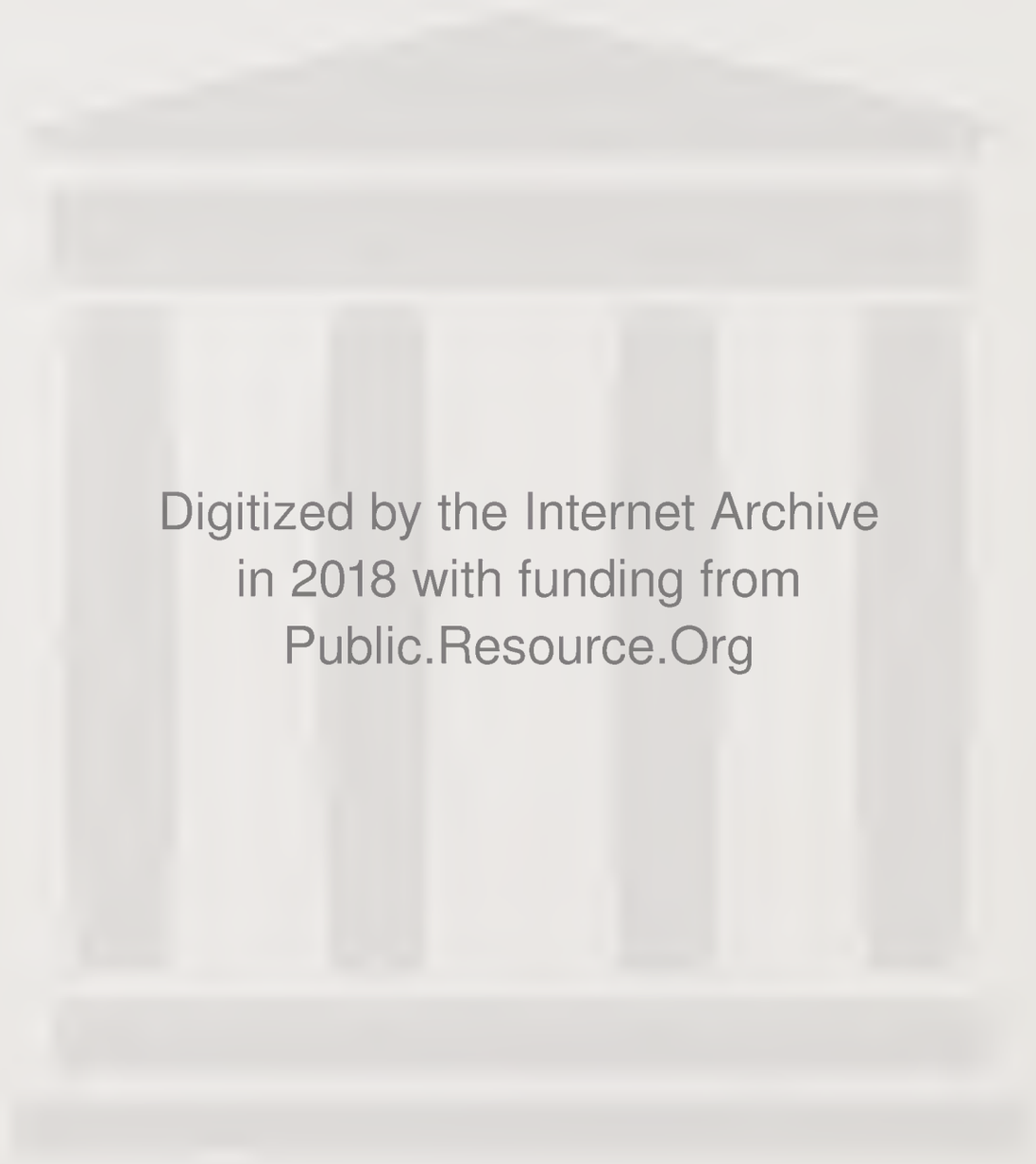
BUILDER OF SCIENTIFIC AND INDUSTRIAL FOUNDATION OF MODERN INDIA

# SHANTI SWARUP BHATNAGAR

SUBODH MAHANTI



# SHANTI SWARUP BHATNAGAR

**Builder of Scientific and Industrial Foundations of Modern India**

**Subodh Mahanti**

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*"I would like to pay a tribute to Dr. Bhatnagar, who I think, has done, I say this with all respect to others, more than anyone else for the scientific development in India. I can truly say that but for Dr. Bhatnagar, you could not have seen today the chain of national laboratories in India."*

**Pt. Jawaharlal Nehru (1955)**

*"As a young boy, my classmates used to tease me for being a day-dreamer. I used to think of great things which Science could do for India and the part I, myself, should play in it with the rest of my friends. The improbabilities of my dreams coming true used to be the principal subject of jokes when I was a student. If I had not possessed a sense of humour and had taken those jests seriously I should have been a physical wreck. But, God be thanked, I have survived to see some of my dreams fulfilled. Failures have been many and successes rather few, but with an inborn optimism and faith in my country's future I pursue on."*

**Shanti Swarup Bhatnagar (1945)**

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I am grateful to the Publications Division, Ministry of Information and Broadcasting, Government of India, for entrusting me the responsibility of a writing the biography of one of the ablest Sons of India. I was familiar with the life and works of Bhatnagar, but reading all the existing sources was a rewarding experience.

I wish to acknowledge my indebtedness to the authors/editors of the following documents on Bhatanagar.

1) *Sir Shanti Swarup Bhatnagar F.R.S.: A Biographical Study of India's Eminent Scientist* by Norah Richards (1948). (A new edition with a review essay by Rajesh Kochhar has been brought out by National Institute of Science, Technology and Development Studies, New Delhi in 2004).

2) *Shanti Swarup Bhatnagar : His Life and Work* by Anand Swarup Bhatnagar (1989).

3) Shanti Swarup Bhatnagar : 1894-1955 in *Biographical Memoirs of the Fellows of the Royal Society of London* by T.R. Seshadri (1962).

4) *S.S. Bhatnagar on Science, Technology and Development: 1938-54,* edited by V.V. Krishna (1993).

I would like to thank Dr. A.K. Mathur, Scientist, National Institute of Science, Technology and Development Studies, New Delhi and Shri R.D. Rikhari, National Research and Development Corporation, New Delhi for making me available certain materials on Bhatnagar. I am pleased to acknowledge the help rendered by my son Sugat Mahanti in the form of collating information and typing the manuscript and for his enthusiastic

suggestion on the linguistic style. I could not have finished writing this book if my wife Dr. Sujata Samtani had not freed me from household work and I would like to thank her for the same. She had also given many useful suggesions for finalising the contents of the book. My elder brother Shri Sukumar Mahanti and my father-in-law Professor N.H. Samtani are great sources of encouragement for me.

I must acknowledge my gratitude to my late mother Shaktibala Mahanti, without whose sufferings and sacrifices I would not have achieved anything in my life. Her memory is a great source of inspiration in any endeavour of mine. I am sure that though she is not physically present, her blessings have guided me in this endeavour as well.

**Subodh Mahanti**

# PREFACE

This book is the story of a man who succeeded against overwhelming odds; a man who was not ashamed of being told a day-dreamer; a man who worshipped science; a man who in his childhood dared to dream great things that science could do for India and the part he himself would play; a man who never lost faith in his own abilities; a man who worked for the betterment of the society and not for his own benefit; a man who had an inborn optimism and faith in his country's future; and a man who could think about the future without being intimidated by the adverse circumstances of the present. Who was this man? He was called Shanti Swarup Bhatnagar, one of the most ablest and illustrious Sons of India.

Bhatnagar lost his father when he was just eight months old. His mother had no inheritance or income of her own for the upbringing of her children. Bhatnagar lived in his maternal grandfather's house till he was 13. Thereafter he was on his own. He managed to study either by getting scholarship or by working outside school and college hours. He had an indomitable will for higher studies. He worked through step by step. By his sheer willpower and hard work, Bhatnagar was elected a Fellow of the Royal Society of London—the highest honour that an Indian scientist could aspire to get other than the Nobel Prize. Whoever came in contact with him was touched by his intellect, diligence, honesty and above all, an inherent simplicity.

Bhatnagar demonstrated that knowledge could create wealth. Perhaps he was the first Indian scientist, who could earn a significant amount of money by applying his scientific knowledge. Whatever he earned by doing scientific research, he did not

keep it for his own benefit but he donated it to the university for using it for scientific research. For him doing science meant worship. It was unthinkable for him to do science for money. When his services were needed for shaping industrial research in the country, he plunged himself with all his energy and dedication without caring for his own interest. With his devotion and hard work he created an excellent infrastructure for industrial research in the country where there was none. His untiring efforts led to the creation of one of the largest scientific organisations in the world—India's Council of Scientific and Industrial Research.

Bhatnagar was a multifaceted personality—a teacher, a scientist, an educationist, a leader of men, an administrator, and a poet. Bhatnagar was a staunch patriot. Though he was a Government official in British India, he had the courage and conviction to publicly touch the feet of the President of the Indian National Congress spearheading the movement for attaining India's independence.

Bhatnagar's life can be and should be a model for anybody living anywhere in the world and at any juncture of human history. Here my attempt has been to bring out the salient features of his life and work. I am fully conscious of the fact that it is always a difficult proposition to write about someone on whom people have already written and there are no unknown facts which could be looked into. The sources from which new insights could be gained are lost with the passage of time. This means that there cannot be any fresh original insights. But certainly the presentation can be different. A story often looks different when it is told by different people. This is because perhaps unknowingly a story-teller influenced by his perception, understanding and experience tends to highlight certain portions of the story. Moreover some stories are such that even after being told again and again do not lose their uniqueness. With such stories it is not important who tells the story, the very nature of the story is such that it is bound

to attract the attention of people. The story of Bhatnagar's life is one such story.

While writing about Bhatnagar's life and work, my role is more of a story-teller and not of a story writer. I have decided to tell his story because I know even if I fail to perform the role of a good story-teller, the message or the moral of the story will not be entirely lost. My story is based on the narrations earlier written on Bhatnagar. To make my story complete I have a beginning, a middle and an end. Like many others I believe that a story cannot be called a complete story if it does not have these three parts. In the introduction that is the beginning of the story, I have presented a brief overview of Bhatnagar's life and work. The idea is that after reading the introduction one will be persuaded to know the complete story. The middle part or the main part of the story deals with different aspects of Bhatnagar's life and work in somewhat detail. The last part of the story tells what Bhatnagar stood for and what he has left us to carry on for the future. With regard to personal qualities of Bhatnagar, there may be slight repetition here and there but it is intentional and not an oversight. This has been done to make people remember certain personal traits, which made him different from others. It is a well-known fact that people remember something if it is told more than once. At some places there may be little digressions from the main story. Some technicalities could not be avoided while describing Bhatnagar's scientific contributions. If a reader finds certain terms or names of people appearing in the text unfamiliar he may find them explained in the Supplementary Notes. A list of references consulted (other than those mentioned in the acknowledgements) for writing this account has been given at the end for the benefit of more inquisitive readers.

I have given brief descriptions of the CSIR laboratories that were founded or made functional during Bhatnagar's life-time but they should not be considered as full descriptions of these organizations. The aim is only to give some idea of the

objectives with which these organisations were established and what Bhatnagar expected of them.

I wish my account of Bhatnagar's life will be read by young people of India, who will shape the future of India. Bhatnagar's example will persuade them to work for the country, to take up challenges and new initiatives and to be useful members of the society. They should know that there is greater pleasure in working for a bigger cause. In any case we need more Bhatnagars to ensure a great future of our country. After reading this book, if there is one young Indian who decides to follow the ideals of Bhatnagar, my efforts will be amply rewarded.

**Subodh Mahanti**

# 1

# INTRODUCTION

*"A special characteristic of Bhatnagar was the all out encouragement and support he gave to young scientists and research scholars. He was deeply human, kind and generous to a fault. His life and example of total dedication to science and the country would long continue to be a source of strength and inspiration."*

**—Daulat Singh Kothari**

SHANTI SWARUP BHATNAGAR was one of the builders of scientific and industrial foundations of modern India. Bhatnagar along with Homi Jehangir Bhabha, Prasanta Chandra Mahalanobis, Vikram Ambalal Sarabhai and others played a significant part in building of post-independent S&T infrastructure and in the formulation of India's science and technology policies. Bhatnagar's position in the annals of Indian science is truly unique. He was a highly accomplished scientist, an able science manager and an administrator, a great creator of institutions and a staunch patriot. He was a great leader of men. He was an effective communicator and he urged fellow scientists to develop an effective communication skill.

Bhatnagar had an abiding faith in the scientific and technological potential of India. As Nitya Anand, formerly Director, Central Drug Research Institute, a CSIR laboratory, says: "If India is shining today, it is because of its S&T strength, the foundations for which were laid by bureaucrats like Ramaswami Mudaliar, scientists like Bhatnagar and political leaders like Pt. Nehru, who were committed to protecting national interest in their own spheres of activity, and saw in science and technology the instrument needed for social transformation."

Bhatnagar dedicated his life in creating scientific and industrial infrastructure in the country. In the post-independence India he played an important role in shaping the scientific and industrial base of the country. In his mission he was fully supported by Pt. Jawaharlal Nehru, the first Prime Minister of India.

Like many other great achievers, Bhatnagar had to struggle to realise his goal in life. His father died when he was just eight months old. The family was in dire poverty. Bhatnagar was brought up by his maternal grandfather till he was 13 years old. After that Bhatnagar supported himself. Throughout his studies he earned scholarship. Bhatnagar's inclination towards science was evident since his childhood and he maintained his inquisitiveness throughout his life. His questioning mind created trouble for his teachers in schools. In fact his teachers at Dyal Singh School at Lahore complained to the Headmaster that young Bhatnagar "was a great trouble to them, perpetually plying them with questions; that he was restless in the classroom and always too ready to retort when admonished."

Bhatnagar in his childhood took delight in conducting scientific experiments. While in school he even created a "laboratory" of his own in one of the galleries of the school hall for conducting experiments, where he gathered all kinds of things which he thought would be useful in conducting experiments—old tubes, broken flasks, batteries and so on. In 1911, Bhatnagar published a letter to the Editor in the *Leader,* a newspaper published from Allahabad, on a method of making substitute carbon electrodes for a battery by heating molasses and carbonaceous substances under pressure. The same problem was again taken up by him, when he was in charge of the industrial research in the country. In his Board of Scientific and Industrial Research (BSIR) Laboratories at the Government Test House, Alipore, he developed a process for carbon electrodes in which indigenous Indian materials were employed to meet the shortage of imports during the Second World War.

Bhatnagar was a university professor for 19 years (1921-40), first at the Banaras Hindu University (BHU), Varanasi and then at the

Punjab University, Lahore. He had a reputation of a very inspiring teacher. Bhatnagar's research contributions in the areas of magneto-chemistry and physical chemistry of emulsions were widely recognised. Bhatnagar developed accurate and simple methods for measuring small changes occurring in magnetic properties of materials. His methods have been used to solve many complex problems connected with colloids, alloys and atomicity of mercury, iodine and selenium under different conditions. He also did considerable work in applied chemistry and he could earn a large amount of money from his applied research. As an unprecedented magnanimous act Bhatnagar donated his earnings from his applied research to the Punjab University, Lahore, where he was working.

Bhatnagar held many important positions in the government. He was instrumental in setting up of the Council of Scientific and Industrial Research (CSIR). He was its founder Director (a post later re-designated as Director General). This became a major agency for research in independent India. At the time of his death a number of national laboratories were fully functional. Today, the CSIR has grown into a chain of about forty laboratories with a total scientific and technical staff strength of about 10,000. The CSIR laboratories cover a large spectrum of science and technology. The major activities of CSIR can be grouped under three sections namely, Missions and National Programmes, CSIR Thrust Areas of Expertise and Capability Development.

Bhatnagar was associated with the development of the Atomic Energy Programme of India. In 1945, an Atomic Energy Committee was set up under the aegis of the Council of Scientific and Industrial Research. The Committee was chaired by Homi Jehangir Bhabha, and it included Meghnad Saha, D.N. Wadia, then Mineral Adviser to the Central Government and Bhatnagar. The Atomic Energy Commission was established in August under the Chairmanship of Bhabha. Its other members were Bhatnagar and K.S. Krishnan.

He was the first Chairman of the University Grants Commission (UGC). He was Secretary, Ministry of Education and Educational

Adviser to the Government of India. Bhatnagar played an important role both in the constitution and deliberations of the Scientific Manpower Committee Report of 1948. This was the first-ever systematic assessment of the scientific manpower needs of the country in all aspects. The report served as an important policy document for the government to plan the post-independent S&T infrastructure.

Bhatnagar played an instrumental role in the establishment of the National Research and Development Corporation (NRDC) of India, which was visualized to bridge the gap between research and development. Bhatnagar was responsible for the initiation of the Industrial Research Movement in the country. The Government of India, being persuaded by the efforts made by Bhatnagar, set up an Industrial Research Utilisation Committee for translating science and technology into industrial applications. Bhatnagar constituted the one man Commission in 1951 to negotiate with oil companies for starting refineries and this ultimately led to establishment of many oil refineries in different parts of the country. He induced many individuals and organisations to donate liberally for the cause of science and education.

Bhatnagar exhibited a high poetic talent particularly in Urdu. Bhatnagar's maternal side produced many poets; the most famous among them was Munshi Hargopal Tufta who was given a title of Mirza by the great Urdu poet Mirza Ghalib. After his wife's death, Bhatnagar published a collection of his Urdu poems, titled *Lajwanti* (after his wife's name). It was his wife who preserved Bhatnagar's handwritten poems. Commenting on Bhatnagar's habit of writing poetry, his biographer Norah Richards wrote: "From childhood S.S.B. (Bhatnagar) had enjoyed listening to poetry and soon began occasionally to write verse. He was in the habit of writing down verses on any scraps of paper and pocketing them. This usually happened while travelling or on holiday. For years his days have been too full for systematic writing, although for a busy man his output is considerable. He versifies all kind of happenings—a meeting with Mr. Churchil, for instance...." During his stay in

Banaras, Bhatnagar composed the 'Kulgeet' (University Song) of the University.

Bhatnagar died on January 01, 1955. Pandit Jawaharlal Nehru, the first Prime Minister of India himself was present at his funeral on 02 January 1955. On his death, the Government of India issued a Gazette Extraordinary on 04 January, 1956, which stated the following: "The President has learnt with deep regret of the death on Saturday, 1st January, 1955 of Dr. Shanti Swarup Bhatnagar, Secretary of the Government of India, Ministry of Natural Resources and Scientific Research, and Chairman, University Grants Commission. On his passing away, India has lost an able and trusted public servant who had served his country with signal distinction in the scientific world.

It was given to Dr. Bhatnagar to fulfil the historic mission of realizing the Prime Minister's vision of putting India on the scientific map of the world and the result can be seen today in the 14 National Laboratories which have sprung up in rapid succession in the years 1950 and 1954. These have laid the foundations of the country's scientific development..."

Bhatnagar has left his indelible mark in India's history. India will always remember Bhatnagar as one of her extraordinary sons, who worked wholeheartedly to make her head high in the world. S. Sivaram in an article published in *Resonance,* a journal of science education published by Indian Academy of Sciences, Bangalore, wrote: "Bhatnagar in his eventful sixty years achieved more than what generation of men could not accomplish. He left his indelible imprint on pure science. He demonstrated that science becomes relevant to society only when its practitioners are willing to descend down from their ivory towers and translate science into applications. He was visionary extraordinary who saw the need for a strong scientific infrastructure for an independent India... He created institutions which became the 'cradle' for science in India and which have stood the test of time in terms of both relevance and need."

# 2

# CHILDHOOD AND EARLY EDUCATION

*"As a child he (S.S. Bhatnagar) showed deep interest in his studies, particularly in a science subjects...."*

**—Nitya Anand**

SHANTI SWARUP BHATNAGAR was born on February 21, 1894 at Bhera in the district of Shapur in the then undivided State of Punjab (today Bhatnagar's birthplace is situated in Pakistan). Bhatnagar belonged to an educated elite family both from the paternal and maternal sides. His paternal grandfather Rai Bahadur Munshi Manoharlal of Panipat in the Karnal district (now in the State of Haryana) and his two brothers Rai Sahib Munshi Nandalal and Munshi Mukundalal held high executive and judicial posts. Munshi Manoharlal was particularly noted for his piety and honesty. Bhatnagar's mother Parbati was the eldest daughter of Munshi Pyare Lal, a distinguished engineer of those days. Pyare Lal was one of the first to qualify as an engineer from the Roorkee College of Engineering.

Bhatnagar's father Parmeswari Sahai Bhatnagar refused to take up well-paid judicial or executive service following the tradition of his family. He became a member of the *Brahmo Samaj*. After his father's death, Parmeswari Sahai left college half-way and became a teacher of an Anglo-Sanskrit high school in Bhera. For his religious beliefs, Parmeswari Sahai Bhatnagar was totally estranged from his family members. Unfazed by this, he continued to serve the society through his teaching and other social services. In 1893, Parmeswari Sahai went to Lahore as volunteer of the

Indian National Congress. Parameswari Sahai sat privately for his BA examination. He passed the examination with distinction in History and English in 1894.

Bhatnagar's father died on October 26, 1894, at the young age of 22. At the time Bhatnagar was just eight months old. Parmeswari Sahai's sudden death left his young wife and children in dire poverty. Her husband's uncles and brothers did not come forward to support her. As a result there was no other option for Bhatnagar's widowed mother than to go to her father, who by then had retired from Government service and settled in his ancestral house in Sikanderabad in Bulandsahar District of the then United Province. Bhatnagar was much influenced by his maternal grandfather, who bestowed great deal of interest to young Bhatnagar. His first biographer Norah Richards wrote: "Under the influence of his grandfather Shanti (Bhatnagar) developed an interest in Engineering and also in Physics and Chemistry. Clay-modelling greatly attracted him and he spent much time at it. In this his grandfather encouraged him but he was often reprimanded by others as wasting his time. He took much interest in his grandfather's geometrical instruments. At the age of eight he used to make mechanical toys. He had constructed a steam engine and one day, to his great joy, the clay vessel that served as a boiler burst. He well remembers the keen pleasure he derived from the explosion that caused the engine to move forward, just a little, on the crude rail."

Bhatnagar had his earliest schooling in a *Maktab* at Sikanderabad. *Maktab* is a Persian word and it means primary school. Bhatnagar joined the *Maktab* in 1901. The medium of instruction in the *Maktab* was Urdu. His second school was the Anglo-Vernacular High School also in Sikanderabad, where he studied up to the year 1907. Under the influence of his maternal grandfather, the young Bhatnagar not only developed a taste for engineering and science but also became interested at a very early age in his grandfather's instruments, geometry and algebra and in making mechanical toys.

Bhatnagar was not an easy student to handle. Norah Richards wrote: "He was terror to his teachers and to this day is quite good at leg-pulling. He used to tease them by asking uncomfortable questions. A precocious lad, he was in some subjects in advance of his instructors, notably in Urdu poetry. He did not hesitate to point out flaws in their exposition, but this he did in a jocular manner that yet was bold. Recognising his precocity and disarmed by his manner they were not offended but in self-protection did their best to avoid occasions of discomfiture." There were occasions when Bhatnagar were beaten by his teachers. But he was good at his studies.

Rai Sahib Lala Raghunath Sahai, the Headmaster of the prestigious Dyal Singh High School at Lahore was a class fellow and a friend of Bhatnagar's father. When Raghunath Sahai met his late friend's family at Panipat in 1908, he found young Bhatnagar's skill in literature and science quite commendable. He persuaded Bhatnagar's mother to send her son for schooling at Lahore in Dyal Singh High School, named after its founder Dyal Singh, a prominent landowner and a leading Brahmo leader of Punjab. Dyal singh also founded the English newspaper, *The Tribune*. Bhatnagar's mother was hesitant to accept the offer to send her son to Lahore. Bhatnagar's son Anand Swarup Bhatnagar, in his biography of his father, wrote: "As Dr. Bhatnagar was the eldest son of his widowed mother, in the first instance, she was hesitant but when she was told that he was so good that if he went to Lahore, perhaps, pass the matriculation examination in one year's time and get a scholarship, she finally agreed."

The Headmaster, who was a great source of inspiration to Bhatnagar, played an instrumental role in shaping his career. Besides the Headmaster, the other teachers who had influenced Bhatnagar were Rai Bahadur Lala Ram Kishore (who later became Vice Chancellor of the Delhi University); Lala Bishen Narain Mathur, who later went to America and came back as a leather expert; Moulvi Talib Ali Paband and Mohammed Ashraf.

Bhatnagar's literary attainments particularly in Urdu were highly acclaimed. In fact he was so proficient in Urdu grammer and Urdu poetry that his teachers felt that his attendance in these classes was unnecessary. Bhatnagar was also good in Sanskrit, which he first studied in his ninth class. In fact he was awarded *Kanhaiya Lal Gold Medal* for standing first in Sanskrit in his matriculation examination.

While studying at Dyal Singh High School at Lahore, Bhatnagar came in contact with two leading members of the *Brahmo Samaj*, Pandit Shiv Nath Sastry and Babu Abinash Chandra Majumdar. Bhatnagar became highly interested in the activities of the *Samaj*. It may be noted that Bhatnagar's father had also joined the *Brahmo Samaj*.

As a whole the days spent at the Dyal Singh School were a great inspiration for young Bhatnagar. His childhood interest in science became a passion. His son Anand Swarup Bhatnagar wrote: "Young Bhatnagar was noted for his interest in science at the school and made many experiments and interesting products, particularly in the electrical field, including string telephones and electrical batteries and cells." It was at the Dyal Singh High School, he was drawn to social service.

# 3

# HIGHER EDUCATION AND RESEARCH

*"Mr. Shanti Swarup Bhatnagar was one of the ablest students in that class of 100 students... He distinguished himself in every branch of the work of his classes—literary, scientific, dramatic, social and he gave the most complete satisfaction to the teachers by the excellence of his behaviour. He is young man of more than usual ability, and I feel sure that if he is given opportunities to develop his talents in some great European or American Centre of scientific research, he will do remarkable work in science and will be in a position to render high service to his country."*

**—N.G. Welinkar, Principal of Dyal Singh College at Lahore in 1915**

In 1911, Bhatnagar passed the Matriculation Examination in the first division and secured a University Scholarship. He then joined the newly established Dyal Singh College. The Principal of the College was N.G. Welinkar. At the Dyal Singh College he studied English, Sanskrit, Physics, Chemistry and Mathematics. Amongst his science teachers were A.C. Datta, N.N. Godbole and Ratanlal. Bhatnagar was greatly influenced by Godbole, who was a staunch advocate of indigenous industrial products. That Bhatnagar imbibed Godbole's passion for indigenous industrial products was amply demonstrated in later part of his career. Influenced by Godbole, Bhatnagar in his college days wrote an article on "Fermentation phenomena of pomegranate juice" in a magazine called "Raushni"

published under the aegis Society for Promoting Scientific Knowledge. This Society was launched by some students of Lahore Medical College with more or less same objects of the Punjab Science Institute earlier launched by Ruchi Ram Sahni and J.C. Oman.

Bhatnagar's interests were not confined to studying science subjects. While studying at the Dyal Singh College, he became an active member of the Saraswati Stage Society, established by Mrs. Norah Richards, the wife of the English literature professor of the college, Philip Ernest Richards, whose duties also included "free-thinking religious discourse." Bhatnagar earned a good reputation as an actor. With Mrs. Richards' encouragement Bhatnagar wrote in Urdu, a one-act play called 'Karamat' (wonder-worker), the English translation of which earned him the prize and medal of the Saraswati Stage Society for the best play of the year 1912. Norah Richards, who later wrote a biography of Bhatnagar, wrote: "His play, entitled *Karamat* was characteristic of the Bhatnagar of the future. It satirized the superstitious healing of a *Bhagat* who was also a rogue, and showed the superiority of the healing that was scientific. This play won the distinction of being banned by the Censor, in the person of the then Principal, the successor to Mr. Welinkar, who feared it would give offence to Hindu sentiment. Had the founder of the College been the Principal, at the time, that play would have been performed. It was in line with cultural liberation from cramping Orthodoxies and supersitions, and who knows but another cultural medium would have been endowed—the drama."

Bhatnagar passed the Intermediate Examination of the Punjab University in 1913 in the first division and joined the Forman Christian College for the BSc degree. At the time of Bhatnagar's joining the College, Dr. J.C.R. Ewing was the Principal. Dr. Ewing (who later became Sir James Ewing) was for many years Vice Chancellor of the Punjab University. It was at the Forman Christian College that Bhatnagar "began his science studies in real earnest." He suppressed his all other interests. Bhatnagar studied physics, chemistry and English and he opted for Honours in physics for this

degree. He was taught physics by J.M. Benade, an experimental physicist. Benade had worked with K.T. Compton and the Nobel Laureate Arthur Holly Compton (1892-1962). It was with Benade, that Bhatnagar did his first research work for his MSc degree on the subject of surface tension. Chemistry was taught by P. Carter Speers, who used to be regarded as father of technical education in the University. Norah Richards writes: "Shanti Swarup found the new atmosphere of the Forman Christian College stimulating. Not only was it pervaded by the missionary spirit in mental and moral philosophy—though no professor on the staff actually professed this philosophy—but also it was pervaded by the missionary spirit in Science, which found in Prof. J.M. Benade a fitting vehicle and later in Prof. P. Carter Speers. These two scientists greatly influenced Bhatnagar, with both of whom he eventually formed close friendship." Among his other teachers at the Forman College were: P.G. Shah, S.M. Mehta, N.A. Yagni, Dr. E.D. Lucas and Dr. Rice, Dr. Rice's wife was a sister of Professors A.H. Compton and K.T. Comption.

Bhatnagar took three years to complete his BSc degree instead of two. This is because he failed in chemistry. To many it may rightly appear as surprising that the person who later rose to an internationally acclaimed chemist had indeed failed in that very subject in college. He was a gifted student. As Dr. E.D. Lucas, who succeeded Sir James Ewing as Principal of Forman College said: "I have heard Benade, who worked with him most closely say that S.S.B. (Bhatnagar) was the Indian student most gifted with the powers of improvisation, thinking out a new problem, devising some new techniques with tools and equipment. He knew how to use his hands, was not afraid of work and was not conceited though he had faith in himself." Bhatnagar failed in chemistry not because of his lack of knowledge in chemistry but for possessing more advanced knowledge in the subject than taught in the class. There was a question dealing with the nature of X-rays that was discovered by Wilhelm Conrad Roentgen (1845-1923) in 1895. Based on his wider reading and not being

confined to textbooks alone, Bhatnagar wrote that like ordinary light X-rays could also be reflected, refracted and polarized. But Mellor's *Textbook of Inorganic Chemistry* being followed in the college did not mention this fact. And the textbook was the bible for the examiner and there was no wonder that the examiner failed Bhatnagar for writing something which was not in the textbook. He obtained his BSc degree with Honours in Physics in 1916. To earn his examination fees for undergraduate studies at Forman Christian College, Bhatnagar made an inventory of the Chemical Laboratories of the College.

Even before completing his BSc, Bhatnagar had solved an industrial problem. During the Second World War things could not be imported from Germany and many other countries. This was creating problem for many business enterprises. The leading stationer at Lahore was unable to import hecktographic pads required for duplication. The stationer approached Prof. Carter Speers of Forman College with a request to solve his problem. Prof. Speers asked Bhatnagar to look into the problem. Bhatnagar solved the problem and the stationer gave him Rs. 150 for solving his problem. It was big money in those days. At the time Bhatnagar has no source of income and so the money received proved to be very useful to him.

After completing his Bachelor's degree in 1916, Bhatnagar decided to take up his first formal employment as Demonstrator in the Physics and Chemistry Department of the Forman Christian College. Later he became the Senior Demonstrator in the Dyal Singh College. Though Bhatnagar was employed he did not give up his idea of pursuing higher studies. He joined the MSc course in chemistry of the Punjab University. The inter-collegiate postgraduate teaching scheme came to his rescue. Under this scheme he was able to receive guidance from B.H. Wilsden and M.B. Jones of the Lahore Government College. His duty as a demonstrator was quite demanding. He had to work five hours or even more a day. As a result he took three years to complete his degree instead of two. His laboratory work as a Demonstrator proved to be useful in completing a thesis on "Effect of Adsorbed

Gases on the Surface Tension of Water." He finally obtained his MSc degree in 1919.

After MSc, Bhatnagar moved to England for higher studies. This was possible because with the initiative taken by Prof. Ruchi Ram Sahni, Bhatnagar was awarded a scholarship by the Dyal Singh College Trust for his studies abroad. Originally the scholarship was meant for studies in USA. So armed with this scholarship Bhatnagar left for America on August 04, 1919. He was to go via England. During the journey he had brief sojourns at France and Germany. After reaching England, Bhatnagar found that it was impossible to find berth on ships sailing to America as all tickets had been booked for American troops which were then being demobilized. He spent ten days to find a ticket somehow. But he could not succeed. He then informed the situation to the Dyal singh Trust and asking their permission to work in England. The Trust agreed to Bhatnagar's request for doing post-graduate research in London. Even before he received his reply from the Dyal Singh Trust, Bhatnagar met Prof. B.M. Jones of Lahore Government College in London. After knowing Bhatnagar's problem Prof. Jones was kind enough to take Bhatnagar to Prof. J.C. Phillips, who was then Head of the Physical Chemistry Department at the Imperial College of Science and Technology in South Kensington. However, Bhatnagar's first preference was to work with Professor F.G. Donnan of the University College of London. Professor Donnan, a distinguished physical chemist and was known for his contributions to the area of surface and interface science, an area in which Bhatnagar had worked. So Bhatnagar presented himself with his research papers to Prof. Donnan. Prof. Donnan after taking a test and going through Bhatnagar's earlier research work agreed to take Bhatnagar under his care for the DSc degree of the London University.

In 1921 Bhatnagar received the D.Sc degree. As a member of Donnan's school he was engaged in the study of adhesion and cohesion in emulsions. His thesis was entitled, "Solubilities of bi-and trivalent salts of higher fatty acids in oils and their effect on surface tension of oils." Nora Richards wrote: "In April of that year the

colloquium was held at which he was to give a discourse as a thesis for his doctorate. On the strength of his publication on Surface Tension, he was exempted from taking the PhD a pre-qualification necessary for a D.Sc. For the doctorate his research had been on Colloidal Chemistry, and Emulsion and Emulsification. The audience at the Colloquium was composed of professors, research students and experts on the subject of exposition. Sir William Bragg presided and Prof. Donnan sat in a conspicuous place.

Bhatnagar, well aware that this was the climax of his student career, was very much on his mettle. He delivered the thesis to his own satisfaction. What then was his amazement when Professor Donnan rose and riddled it with shattering criticism. Bhatnagar rose to defend his thesis and at the end Donnan embraced him. Sir William Bragg patted him on the back and said his defence was wonderful and deserved to be a Doctor of Science."

Among his co-workers at the University College of London were: W.E. Garner, who later became Professor of Physical Chemistry in Bristol University; J.C. Ghosh, who later became Director General of Industry and Supply and Member of Planning Commission; J.N. Mukherjee, later Director, Indian Agriculture Research Institute and Member, Union Public Service Commission, Government of India; M.N. Saha, whose pioneering research contribution in astrophysics made India proud and J. Samejima, later President of the Chemical Society of Japan.

While working in London he also had a Fellowship of the value of 250 pounds a year from the Department of Scientific and Industrial Research, England. This enabled Bhatnagar to visit France and Germany. He worked as a research student in the Kaiser Wilhelm Institute, Dhlem, Berlin, and also in the University of Sorbonne, Paris. During his visit to France and Germany Bhatnagar could meet eminent scientists including Fritz Haber (1868-1934), Herbert Max Finlay Freundlich (1880-1941), Max Ernst August Bodenstein (1871-1842), Walther Hermann Nerst (1864-1941), Albert Einstein (1879-1955), Max Karl Ernst Ludwing Planck (1858-1947), and Jean Baptiste Perrin (1870-1942).

# 4

# AS A UNIVERSITY TEACHER

*"Bhatnagar had a reputation as a very inspiring teacher and it was as teacher that he himself was most happy."*
**—T.R. Seshadri, a well-known chemist of India**

BHATNAGAR had been selected in absentia. Pandit Madan Mohan Malaviya, the founder Vice Chancellor of the Banaras Hindu University needed to appoint a University Professor in chemistry. At the time Bhatnagar was in England, Pandit Malaviya wrote to three stalwarts of Indian science—Chandrasekhara Venkata Raman, Acharya Jagadis Chandra Bose and Acharya Prafulla Chandra Ray—requesting them to recommend a suitable candidate for the post. All three of them were also in England at that point of time. After consulting each other, all three unanimously agreed upon the candidature of Bhatnagar and the same was conveyed to Pandit Malaviya. Based on their recommendations Bhatnagar was sent an offer to join BHU. Incidentally, this was not the only offer that Bhatnagar had at that point of time. There were three other offers—from the Forest Research Institute at Dehradun, from the Dyal Singh College at Lahore as its Principal and from the North-Western Railways as analytical chemist. There were two other possibilities, which Bhatnagar could have explored—one from Jagadis Chandra Bose as Superintendent of the Institute founded by him at Kolkata and the other one from Asutosh Mookerjee, Vice Chancellor of the Calcutta University as Professor of Physical Chemistry in the Calcutta University.

Bhatnagar accepted the offer from Pandit Malaviya. He joined the Banaras Hindu University in August 1921. There is an interesting episode that took place at the time of his joining the Chemistry

Department of the Banaras Hindu University. Dr. Nitya Anand, formerly Director of the Central Drug Research Institute, Lucknow has described this episode in this way: "He started his innings at BHU with a magnanimous gesture which had no precedent. When the former Head of the Department of Chemistry from whom he was to take charge expressed his distress at handling over the keys which he had held for fifteen years, Bhatnagar's spontaneous response was: "then hold them still". And he really meant it. He persuaded the Executive Council of the University to allow the former head to continue as Head of the Department. This unique gesture was greatly appreciated by his new colleagues and by Pt. M.M. Malaviya, the Vice Chancellor. Bhatnagar's generosity and large heartedness extended to students, especially to science students who could not pay their fees and he paid stipends out of his own pocket to students showing promise."

Bhatnagar spent three years at the Chemistry Department of the Banaras Hindu University. However, within the short span of time he was able to create an active school of physico-chemical research. Unlike in his later part of his career, he had no administrative responsibilities at the Banaras Hindu University. He only concentrated on teaching and research. Pandit Malaviya was much impressed by Bhatnagar's abilities and his dedication. He would often urge the visitors to the University, "You must see Bhatnagar's Laboratory." At the Banaras Hindu University, Bhatnagar did research mainly in colloids, geo-chemistry and photochemistry.

In 1924, Bhatnagar moved to Lahore to take up the appointment as the Director of the University Chemical Laboratories of the Punjab University. Bhatnagar was 30 years old. The appointment was an important milestone in Bhatnagar's career. Bhatnagar's selection for the post testified his high accomplishment as a researcher. The post had been advertised in *Nature,* a highly acclaimed international scientific journal published from London. At the time of advertisement the Laboratories were under construction. Bhatnagar was in England and he applied from there. It was natural that applications from the post came not only from

British India but from England and other countries under the British Empire. Two Committees of Experts were constituted for the selection—one in England and the other one in India. The Committee in England included Sir Herbert Jackson, FRS, Sir Jocelyn Thorpe and Sir James Walker and the Committee in India consisted of Acharya Prafulla Chandra Ray, Prof. J.L. Simonsen and Prof. H.R. Watson. Three persons were short-listed for the post—Wilsden, Cavanagh and Bhatnagar. At some stage the name of Cavanagh was ruled out and thus the choice was between Wilsden and Bhatnagar. It was stiff competition. The University Professor's Committee, Chaired by the Vice Chancellor of the University, then Sir John Maynard could not take a decision as there was a draw after the matter was put to vote. Sir John Maynard refused to cast vote on either side. It was decided to put the matter to Syndicate of the University. But before that Wilsden withdrew from the competition and so Bhatnagar was selected.

Bhatnagar, jointly with K.N. Mathur wrote a book "Physical Principles and Applications of Magneto Chemistry." The book was published by Macmillan Publishers in 1935. Bhatnagar's book was the first book to be written in English on the subject. It was considered as a standard work. P.C. Ray wrote: "On turning over the pages of *Nature* my eyes chanced upon an advertisement of Macmillan's in which I find your book at last advertised. That the book is of a high standard is indicated by the most excellent review in *Current Science* by Professor Stoner, who is competent to judge. As far as I know Meghnad's is the only textbook in physical sciences which has been adopted by foreign universities; and it gladdens my heart that another work in physical science is likely occupy my great consolation is that you, in chemistry, are raising the reputation, abroad of Indian workers." C.V. Raman wrote: "I specially admire your energy and perseverance in having produced such a book in spite of your other important scientific and practical activities. Your name now stands as one of the very few Indians who have written scientific books claiming the respect and attention of serious workers in every country."

While working at the Punjab University, Lahore, Bhatnagar earned considerable sum of money from his applied research work. However, Bhatnagar donated all his earnings from such activities to the University. His son A.S. Bhatnagar wrote: "My father's persistent refusal to accept any financial award to him personally was due to the conviction that scientific work loses its altruistic and truly cultural character if the worker becomes money-minded and begins to get financial benefits for himself. Also the public begins to doubt the sincerity of a worker if he works hard in order to make himself rich. The students derive inspiration from only a selfless worker." Bhatnagar's act was an exemplary one without any parallel in the history of Indian universities. People from all walks of life, particularly from the scientific world took note of this exemplary sacrifice and extended their hearty congratulation. Meghnad Saha, known for his pioneering contributions in astrophysics, wrote to Bhatnagar: "Please accept my heartiest congratulations on your noble gift to the Punjab University. You have thereby raised the status of the university teachers in the estimation of the public. India does not lack men earning in millions, but if a few of these millionaires were guided by the fine examples set by a comparatively poor teacher like yourself, I think her scientific and moral progress would have been rapid." Sir Tej Bahadur Sapru in his convocation address to the Punjab University in 1936 while giving the example of Bhatnagar's sacrifice said: "When therefore, I read the other day in the newspapers that Messers Steel Brothers had in recognition of the great work done by Dr. Bhatnagar, made a very generous gift of money to him and he had with a singular sense of patriotism and self denial transmitted a considerable part of that gift to the Chemistry Department of your University so as to create an Industrial Research Department in which some research scholars could develop new processes for industrial utilization of Indian raw materials, I felt that your university is lucky in possessing a professor who out of singular sense of patriotism and self-denial, contributed a considerable part of his gift to the university, who was alive to his duty to the country and

was not afraid of being accused of doing something practical for the country."

J.C. Ghosh, a student of Acharya Prafulla Chandra Ray and an internationally acclaimed chemist, wrote: "Your generosity has no parallel in India. To make over to your alma matter, a sum of Rs. 1,50,000 which was the reward for your distinguished service in the field of applied research, is a unique gift and no praise can be too high: To be able to claim you as a friend has been a matter of pride—it is seen even more so now."

His exemplary act was noted with high appreciation in England as well. Bhatnagar's research guide in England F.G. Donnan said: "The event must be quite unprecedented in the history of University research in India, and reflects the greatest honour upon yourself and upon the position to which you have attained. I need scarcely tell you that as one of your old professors I feel highly pleased by the great success of my former research student, Bhatnagar."

# 5

# SCIENTIFIC CONTRIBUTIONS

*"Bhatnagar made a large number of publications. Most of them were in the field of physical chemistry and the major subjects were magneto-chemistry and physical chemistry of emulsions."*

**—T.R. Seshadri**

THE two major areas in which Bhatnagar made significant contributions were magneto-chemistry and physical chemistry of emulsions. In early phase of his research career Bhatnagar had realised the importance of the application of magnetism to chemistry. Being aware of great possibilities, Bhatnagar decided to make use of magnetic susceptibility measurements for studying the properties of organic compounds, solutions, films and colloids. However, there was no suitable instrument for measuring small changes in magnetic susceptibilities. So the first task before Bhatnagar was to design and build a suitable instrument. This was successfully accomplished. Bhatnagar, jointly with one of his students, K.N. Mathur (who later became the Director of the Central Scientific Instruments Organisation, Chandigarh) invented an instrument for measuring small variations in magnetic susceptibilities. The instrument, called the Bhatnagar-Mathur Magnetic Interference Balance, was one of the most sensitive instruments devised for measuring magnetic properties. The invention was patented and it was licensed to Messrs Adam Hilger and Co., Camden Town, London, for production and marketing. The balance was first exhibited at the Royal Society soiree at London in 1931.

Bhatnagar and his group examined the scope of P. Pascal's law of additivity and they obtained dependable values of atomic and

constitutive constants. Bhatnagar and his group demonstrated that the law could be applied not only to organic compounds but also to inorganic compounds. They found that in case of inorganic compounds, the sum of ionic susceptibilities made up the molecular susceptibility. They studied the temperature dependence of magnetic susceptibilities of different compounds and found appreciable differences between different groups of compounds. These findings formed the basis of a method of classification.

i) Non-polar and symmetric molecules, for example cyclohexane and carbon tetrachloride. This type of compounds did not show any changes in their magnetic susceptibilities with the change in temperature.

ii) Associated liquids, for example water and aliphatic alcohols. This type of compounds showed an increase in the magnetic susceptibilities with increase in temperature.

iii) Aromatic compounds like benzene, toluene and xylene. This type of aromatic compounds and a large number of other substances showed decrease in their magnetic susceptibilities with increase in temperature.

The temperature dependence of magnetic susceptibilities of three group of compounds was correlated with their magnetic birefringence. Bhatnagar and his group extended the application of the method of magnetic susceptibility to study complex problems related to

i) colloid formation, for example the adsorption and absorption of atmospheric gases on the surface of particles during the process of size reduction and changes in microcrystalline structure,

ii) solutions including solid solutions,

iii) atomicity of elementary molecules like those of mercury, iodine and selenium under different conditions.

iv) allotropy, and

v) photochemical decomposition and phototropy.

An interesting and innovative use of the magnetic measurement was the study of the nature of oxide films formed on strips of heated copper. By studying the paramagnetic nature of these films, it was demonstrated that they contained higher oxide of copper that is CuO (cupric oxide) and not $Cu_2O$ (cuprous oxide). Again by using this method Bhatnagar was able to provide a definitive evidence for the existence of ionic micelles—by studying the magnetic rotation of solutions of salts of higher fatty acids in water and alcohol. Ionic micelles are aggregates of ions formed in soaps, detergents, and other suspensions.

Bhatnagar and his group studied the influence of magnetic field on the character or speed of chemical reactions. After studying a large number of reactions of various types in and outside the magnetic field, they concluded that the influence of the magnetic field depended on the difference between the sum of molecular susceptibilities of the initial reactants and the final products. In case there was no difference the magnetic field had no effect. The importance of the orienting effect of the field on the atoms and ions concerned was also studied by Bhatnagar and his group. These observations were useful for studying adsorption, a process that involves chemical action. The contributions of Bhatnagar and his group in the area of magneto-chemistry were reviewed in:

i) "Physical Principles and Applications of Magneto-chemistry" by S.S. Bhatnagar and K.N. Mathur, Macmillan and Co., Ltd., 1935.

ii) "A Survey of Recent Advances in Magnetism Relating to Chemistry", the Presidential Address by Bhatnagar to Chemistry Section of the Indian Science Congress, 1938.

iii) "Some New Magneto-chemical Problems" by Bhatnagar and Kapur in *Zeitschrift fur Electrochemie* in 1939.

Bhatnagar made significant contributions in the area of emulsions. While working for his D.Sc degree in Prof. Donnan's laboratories in London, Bhatnagar extensively studied the adhesion and cohesion of emulsions. The phenomenon of the inversion of emulsions by

electrolytes was extensively studied by Bhatnagar. Their studies greatly enhanced our understanding, both theoretical and practical, of the behaviour of emulsions.

Bhatnagar, using William Clayton's electrical method for detecting the inversion point, extensively studied the inversion of emulsions by electrolytes. He also measured the exact amount of electrolytes required for inversions to take place. The oil-in-water type emulsion, particularly when the aqueous phase contains small quantities of electrolytes, shows an electrical conductivity but the water-in-oil type does not conduct electricity.

His extensive studies of the properties of emulsion led him to propose the following two empirical rules.

i) A water-in-oil emulsion can be converted into oil-in-water emulsion by electrolytes having anions like $OH^-$ and $PO_4^{-3}$.

ii) An emulsion of oil-in-water can be reversed into water-in-oil emulsion by electrolytes having cations like $H^+$, $Al^{3+}$, $Fe^{3+}$ and $Th^{4+}$.

Generally it was believed that emulsification is influenced by the following factors:

i) Mass of the emulsifying agent.

ii) The ease with which the emulsifying agent can be absorbed at the interface.

iii) The nature of ions absorbed by the resulting film.

Bhatnagar emphasized that the two main factors which governed the process of emulsification were: a) the relative wetting power of the two phases with respect to the emulsifying agent, and b) surface potential of the membrane between the phases. The reversal of phase was the result of changes in this membrane with respect to one or both of the above factors. Based on his observations Bhatnagar proposed a generalized rule for emulsification: "All emulsigying agents with an excess of negative ions on them and wetted by water will yield oil-in-water emulsions

while those having excess of adsorbed positive ions and wetted by oil will give water-in-oil emulsions." This rule formulated by Bhatnagar has remained true till today.

Bhatnagar's researches in the area of emulsions have been described in detail in two books written by William Clayton—*Emulsion and Emulsification* and *Emulsions and their Technical Treatment.*

In addition to his significant contributions to the areas of magneto-chemistry and physical chemistry of emulsions, Bhatnagar did outstanding work in the area of applied research—in industrial and practical chemistry. The most spectacular success achieved by Bhatnagar in his applied research was the solution of the 'mud problem' of the Attock Oil Company at Rawalpindi, a subsidiary of Messers Steel Brothers & Co. Ltd., London. Attock Oil Company in their drilling operations for oil confronted a big problem—the mud on coming into contact with saline deposits became a hardened solid mass and this made the drilling operations practically impossible. Bhatnagar based on his thorough theoretical understanding solved the problem. He realized the problems faced by the Oil Company was a problem in colloid chemistry and he developed an experimental method to solve it by adding an Indian gum having the remarkable property of lowering the viscosity of the mud suspension and of increasing at the same time its stability against the flocculating action of electrolytes.

This incident has been beautifully described by one of Bhatnagar's teachers at the Forman College, P. Carter Speers. Speers was one of those who had been approached by the Company to solve the problem. Speers in an article published in the CSIR's *Journal of Scientific and Industrial Research* in its April 1943 issue wrote: "It was during this period that Dr. Bhatnagar demonstrated that the very first requirement of Industrial Chemist is a very thorough grasp of theoretical chemistry. How well, I remember, how it all began! The Attock Oil Company was faced with great difficulty due to the coagulation of mud in their drilling operations when they

encountered salt deposits. The difficulty seemed insuperable and much money and effort had been spent to overcome this difficulty. The University chemists were consulted. Dr. Bhatnagar, Dr. Dunnicliff and I sat down with Company's chemists to discuss the problem. Dr. Dunnicliff suggested several chemical methods for meeting the difficulty which seemed impractical, as Professor of Technical Chemistry, I suggested various mechanical ways which were even more impractical; but the theoretical chemist—Dr. Bhatnagar—insisted from the beginning that it was a simple problem in colloid chemistry and before long he convinced us all that he was right. Before the day was over, he had demonstrated his idea in the laboratory and before the week was over it was being tested in the oil field. Dr. Bhatnagar's method? Some highly complicated scientific legerdemain? Not a bit of it. He merely protected the type of colloid that made up the drilling mud so that the salt could no longer coagulate the clay; he also brought about a type of transformation which takes place when an oil-in-water emulsion is transformed into the water-in-oil type thus introducing the idea of oil mud which is looked upon with great favour everywhere."

M/S Steel Brothers were highly impressed by Bhatnagar's success and they offered him a sum of Rs. 1,50,000 for carrying out research work on petroleum-related subject of his choice. Bhatnagar refused to take up the money for himself but insisted that the money should be placed at the disposal of the Punjab University.

M/S Steel Brothers in a letter dated August 10, 1934 to the Vice Chancellor of the Punjab University wrote: "Subject to certain conditions, we have agreed to place at the disposal of Professor S.S. Bhatnagar, University Professor of Chemistry of the Punjab University, a sum of money for research work on petroleum and allied subjects which will be paid in equal installments over a period of five years. This is being done in recognition of the ability and keen interest shown by Prof. Bhatnagar in the solution of certain problems connected with mud and oil and at the recommendation of our representatives who have seen something of the excellent equipment and the type of work which is being done at the

University Chemical Laboratories at Lahore. That results of permanent interests to pure science and industry may accrue from this association is evident from the fact that our technical representatives advise us that Prof. Bhatnagar very generously wishes to place this money at the disposal of the University with a view to inaugurating a department of petroleum research under his guidance and that he has, in the interest of the University, refused offers which might have benefited him personally to a great extent.

The finance arrangements given to Prof. Bhatnagar will permit of the following expenditure by the University in the scheme outlined above:

| | Per annum |
|---|---|
| Salaries of Research Assistants | Rs. 9600 |
| Chemicals and Apparatus etc. | Rs. 3000 |
| Honorarium to Prof. Bhatnagar | Rs. 6000 |
| | Rs. 18000 |

In addition to this, we will pay the salary and expenses of a fully qualified British Petroleum Research Chemist who would, as required, act as an assistant to Professor Bhatnagar and relieve him of the laboratory routine and detailed work connected with running of the proposed new department. This is estimated to cost Rs. 10,000 to Rs. 12,000/-per annum.

It will therefore, be appreciated by you that the total cost per annum to the Company will amount to say Rs. 30,000/- and over a period of 5 years to approximately Rs. 1,50,000/-.

A feature of the proposal is that any result which, in our opinion, justify the taking out of Patents will be exploited by us and such Patents would be jointly in the same of M/S Steel Brothers and Professor Bhatnagar and/or his chemists and such profits would be shared equally between the Company on the one hand and the parties concerned on the other.

We understand Professor Bhatnagar proposes to spend large portion of any profits that may accrue to him from any patents for the encouragement and development of industrial and chemical research in your province under the auspices of the Punjab University.

We trust that this association with Professor Bhatnagar and the University will be acceptable to you and your Senate and that will prove beneficial to all parties. We are forwarding this letter to you through Professor Bhatnagar."

The proposal made by the Messrs Steel Brother based on the suggestion of Bhatnagar was accepted by the University in its Syndicate Meeting on October 05, 1934. The Syndicate also recorded its "gratification that the excellent work done by Professor Bhatnagar in research on Petroleum had been recognised" and thanked Bhatnagar for converting a personal offer largely to the benefit of the University and scientific research. The Syndicate authorized Bhatnagar to start necessary action for initiating research work under the proposal put forward by Messrs Steel Brothers. Further the Syndicate approved the distribution of six research studentships to be made as under:

1. Emerson Research Studentship at Rs. 200 per month
2. Worner Research Studentship at Rs. 150 per month
3. Sir Fazi-i-Hussain Research Studentship
4. Donann Research Studentship
5. Sir Shadi Lal Research Studentship
6. Dunnicliff Research Studentship

A total of Rs. 450/- per month was allocated for the remunerations for the last four studentships with the condition that individual remuneration would be determined according to qualification.

Bhatnagar started the work in real earnest. He was ably assisted by the research scholars supported by the grants provided by

Messrs Steel Brothers. They worked on a number of subjects related to petroleum and its products for example decolourisation of waxes, increasing the flame height of kerosene by eliminating smoke-causing material to increase the luminosity without consuming more oil and so on. The work carried out by Bhatnagar after receiving the grant from Messrs Steel Brothers greatly enhanced the commercial interest of the company. They wanted to discuss with Bhatnagar on the extension of their research collaboration. During his visit to England in 1936, Bhatnagar held detailed discussions with the representatives of the Company. He also undertook a visit of their factories located in England, Germany and Poland. Bhatnagar solved a number of problems faced by the Company mostly related to food products, cooking and salad oils. The result of these discussions was that Messrs Steel Brothers decided to extend the support for a longer period with enhanced financial commitments. Messrs Steel Brothers in their letter dated August 04, 1936 to the Vice Chancellor of the Punjab University stated: "As a result of Professor Bhatnagar's visit to this country and our discussion with the work which is being carried out under the scheme inaugurated in your university for researching of petroleum and applied subjects, we have the pleasure of advising you that we are prepared to extend the scheme for a further period of five years from the expiry of the present arrangements. This will give the scheme ten years' life and so enable some at least of the long and patient research projects adequate time to be developed commercially and prove an incentive to the workers. The Punjab University will thus be associated with industrial developments for a long period.

In addition to extending the period under the same terms as those at present laid down in the current arrangement with Prof. Bhatnagar, we have further agreed to increase the total remuneration to the research staff by Rs. 65 per month from 1st December, 1936 to 30th November, 1937 and thereafter by annual increments totalling Rs. 45 per month...

We are also pleased to meet the wishes of Professor Bhatnagar that as from 1st December, 1936 we shall provide free medical attention to researchers themselves but not to their families.

We will make suitable arrangements for this medical attention with one of the Lahore doctors.

Professor Bhatnagar has suggested that in order to consolidate the scheme and give adequate protection to the researchers a provident fund should be instituted in order to give the researchers the security which the Provident Fund provide. We are, therefore, agreeable to start a fund for these researchers as from 1st December 1936 on the basis of 10 percent contribution of salary by the researchers and an equal amount by us. Professor Bhatnagar has suggested that this Provident Fund could well be operated under the Registrar of the University according to usual rules and practices, in which case the University would pay the interest earned on such funds.

Compared with the figure of Rs. 1,50,000 given in our letter to you of 10th August 1934 at the estimated cost of the scheme of the Company over the original period of five years, the estimate that the total cost of the Company on the extended period and at the increased rates mentioned above will be approximately Rs. 4,00,000 which includes payment of salary and expenses of a senior European Chemist whom, we have decided to post at Lahore.

We trust that the Senate and the Syndicate will be pleased with this extension of the Research Scheme. We feel that the results of the scheme under the able direction of Professor Bhatnagar will eventually prove not only of commercial value but also of general scientific value in the academic world.... Professor Bhatnagar has advised us that as a result of our offer to extend the scheme, he had decided to stay at Lahore and not to accept the offer of the post of Director of the Industrial research Laboratories at Delhi which Lala Shri Ram proposes to establish..."

The collaboration between Bhatnagar and Messrs Steel Brothers & Co. Ltd. not only established the university-industry relation on a firm footing but also resulted in contributing to the professionalisation of chemistry in India. The unprecedented success achieved by Bhatnagar and his group led to a great intellectual stir in the region.

Bhatnagar and his group working in the Punjab University, Lahore, addressed several problems brought to their notice by agriculturists and industrialists. Among his clients included Lala Shri Ram of Delhi Cloth Mills, Delhi; J K Mills Ltd., Kanpur (then Cawnpore); Ganesh Flour Mills Ltd., Lyallapur; Tata Oil Mills Ltd., Mumbai (then Bombay).

Bhatnagar's contributions in industrial and applied chemistry were widely recognised both in India and abroad. J.C. Ghosh, one of prominent chemists of India, in his Presidential address to the Indian Science Congress held at Lahore in 1939 said: "Within the precincts of this university, it is not necessary that I should have to make a special pleading that scientific knowledge and industrial activities should be co-ordinated or that our academic laboratories should not be divorced from practical affairs. We have here a flourishing Honours School of Technical Chemistry; and the genius of Professor Bhatnagar has provided a bridge of communication between scientists and industrialists. Nowhere is the beneficial effect of contact between universities and industry better exemplified than in the programme of researches on oil technology, now carried out under the supervision of Professor Bhatnagar, with the aid of funds provided by Messrs Steel Brothers."

# 6

# SHAPING INDUSTRIAL RESEARCH IN INDIA

*"...Science has no future in India unless our agriculture and our industries are fully developed; more food and more health are dependent upon these factors. Scientific and industrial research thrives best when it is applied to material benefit to humankind and to existing industries and existing agricultural enterprise."*

**—S.S. Bhatnagar in his Presidential Address to the Indian Science Congress at Nagpur (1945)**

In the 1930s, there were no appropriate research organisations in India for the development of natural resources and new industries. This was the realisation of Sir Richard Gregory, then editor of *Nature,* who visited scientific departments and universities in India in 1933. This prompted Sir Gregory to draw the attention of Sir Samuel Hoare, Secretary of State for India, to the lack of appropriate research organisation equivalent to that of Department of Scientific and Industrial Research (DSIR) in Britain for the development of natural resources and new industries. Sir Hoare observed: "I knew that work of the Geological Survey of India, Botanical Survey of India, Meteorological Department, Forestry and so on; but I think something should be done to form an Indian Research Council to make use of the undoubted capacity of Indians for scientific investigations and its applications. Scientific activities, many of them having direct bearing upon the development of the resources of the country, are scarcely given attention they deserve."

Gregory's observations lent support to the proposal mooted by C.V. Raman, Lt. Col. Seymour Sewell and J.C. Ghosh for creating an Advisory Board of Scientific Research for India. There were other related developments. Indian scientists under the leadership of Meghnad Saha started working for launching a National Institute of Sciences and C.V. Raman started gathering support for establishing an Indian Academy of Sciences at Bangalore. At the Fifth Industries Conference in July 1933, the provincial Governments of Bengal, Bihar, Bombay, Madras and Orissa unanimously reiterated their demand to set up a co-ordinating body for industrial research. The provincial Economic Conference in May 1934 proposed a similar line of action. Taking note of these developments Hoare supported the proposal made by Gregory for creating an Indian version of Britain's DSIR and he advised British India's Viceroy Lord Willingdon for initiating action in this regard. However, the idea was not accepted by the Finance Department and Hoare was informed by Willingdon in London that "the creation of a Department of Scientific and Industrial Research in India to promote the application of research to natural resources and industry does not appear to be necessary."

Though the British India Government rejected the idea of creating an Indian version of DSIR in Britain, it decided to create an Industrial Intelligence and Research Bureau (IIRB) in July 1934. The proposal for creating such a bureau was prepared by Sir J.S. Keathly, Chief Controller of the Indian Stores Department. Keathley's proposal was formally approved by the Sixth Industries Conference. The Bureau came into operation in April 1935. The Bureau was placed under the control of Indian Stores Department and its annual budget was Rs. 1.0 lakh. The headquarters of the Bureau were located at Simla. The Bureau was not an industrial research unit. Its main concerns were testing and quality control. Its major functions were the collection and dissemination of industrial intelligence information; research liaison with provincial Directors of Industries, publishing research bulletins, and organizing industrial exhibition. A research branch of the Bureau was established at

the Government Test House at Alipore, Calcutta and it was placed under the direction of N. Brodie, Superintendent of the Test House. Brodie was also made Director of the Bureau.

After the Second World War began, the Government curtailed expenditure on every aspect. The IIRB was not an exception. It was recommended that the IIRB be abolished. Sir Ramaswamy Mudaliar, then Commerce Member of the Viceroy's Executive Council, accepted the recommendation. However, Mudaliar argued, that "the old Bureau should be abolished not as a measure of economy but to make room for a Board of Scientific and Industrial Research with vaster resources and wider objectives." Mudaliar believed that "in war time, no economy can be too disastrous which starves industrial research and no expenditure can be too high which mobilizes the scientific and industrial talent of the country for research and production of war materials." Mudaliar finally succeeded in persuading the Government to create the Board of Scientific and Industrial Research (BSIR). The Board came into existence on April 01, 1940 initially for two years. The BSIR was placed under the Department of Commerce. The first Chairman of the Board was Mudaliar himself. An annual grant Rs. 5 lakhs was allocated by the Government for the activities to be undertaken under the aegis of the BSIR. The functions of the BSIR were outlined in its first meeting on April 01, 1940. They were:

i. to advise the Government on proposals for instituting specific researches;

ii. to help in the study of problems affecting particular industries and trades;

iii. to make proposals for the establishments of research studentships, scholarships and fellowships; and

iv. to receive proposals from various research institutions and universities.

The scope of the work of BSIR was mostly confined to war related research but it was allowed to collaborate with university laboratories engaged in industrial research.

The background behind the establishment of the Board of Scientific and Industrial Research was beautifully summarised by Ardershir Dalal, in his Presidential address to the Indian Science Congress in 1941. Dalal, an industrialist and who was associated with the Board since its inception, said: "Industrial Research was organized on a country-wide basis in America as well as several countries of British Empire following the last war (First World War). In India also the war revealed the helplessness of the country. The transport service was disorganized owing to lack of Railway material; supplies of dyes, important chemical and many important medicines were almost completely stopped and price of textiles shot up so high as to be beyond the means of poor people. In 1915 the Government of India addressed the Secretary of State as follows; "After the war India will consider herself entitled to demand the utmost help which the government can afford to enable her to take a place, so far as circumstances permit, as a manufacturing country." The policy was accepted by Secretary of State and the Indian Industrial Commission, under the Chairmanship of Sir Thomas Holland, was set up as result. Unfortunately, however, the impetus to industrialisation provided by the war died down after a few years and many of the industries which was started during the war languished and died. The gathering storm clouds of a new world war drew the attention of Indian scientists to the unorganized state of scientific and industrial research and repeated appeals were made for the constitution of a body on the model of DSIR. The urgent need for the appointment of such a body was voiced by Professor J.C. Ghosh in his presidential address to the Association at Lahore in 1939 and was reiterated in the resolution of this body last year at Madras. The same point was made by Colonel Chopra in his presidential address to the National Institute of Sciences in Madras last year and by Sir M. Visvesvaraya in an address to the Indian Institute of Science, Bangalore. We therefore, cordially welcome recent appointment of the Board of Scienctific and Industrial Research by the Government of India in response to the demand of scientists throughout the country. Our thanks are due

to the present Commerce Member, Sir Ramaswamy Mudaliar, who lost very little time in appreciating the urgency of constitution of such a body under the condition created by the war."

Bhatnagar was brought from Lahore as Director of Scientific and Industrial Research. It was Mudaliar, who was responsible for placing Bhatnagar at the helm of industrial research in the country. Mudaliar, who visited the University Chemical Laboratories at Lahore in December 1939, was much impressed by the work done there under the leadership of Bhatnagar. He thus recommended to the Viceroy, then Lord Linlithgow that Bhatnagar's services may be utilized by the Government of India for strengthening the industrial research in the country. The Viceroy accepted the recommendation made by Mudaliar and he requested the Punjab Governor, Sir Henry Craik to allow the services of Bhatnagar to be transferred to the Government of India as Adviser in Scientific and Industrial Research. At the first instance Bhatnagar was little hesitant to leave Lahore and move to a new place with new responsibilities. But then Bhatnagar had no choice other than to accept the arrangement as this was an order of the Viceroy of India. In his address to the Opening Ceremony of the National Chemical Laboratory on January 03, 1950, Bhatnagar said: "When in 1940 I was asked by the then Viceroy, Lord Linlithgow, to take up the post of Scientific Adviser and Director, Scientific and Industrial Research, I was hesitant to leave the peaceful cloisters of learning in my University for the maddening hurry and strife of government work. The request from the Viceroy was, however, was a command and the Chancellor of my university told me that no patriotic individual could refuse the call for help in the war effort; as I was expected to make good by the aid of science the shortages of supplies in India and the Middle East resulting from the War. I was still wondering as to what to do when Sir Ramaswamy Mudaliar cornered me in my den in Punjab University and urged me to accept this office. He assured me that this temporary activity might ultimately result in big developments for scientific research in this country. His statement convinced me that I must leave the

university for a larger field to help in building up India's scientific research, training her young scientists and inspiring her young men to take up research as a career not for monetary gain but for the sake of research itself. In that hour when I decided to take up my office, I dreamt of a chain of national laboratories, of large teams of scientists working for the development of India and the creation of a scientific outlook on life among the masses." Before taking up the office, he requested that laboratory for research be made available to him and he should be allowed to take his six research scholars with him. The Government accepted his requests.

Bhatnagar's departure was a great loss for the State of Punjab. Bhatnagar within a short span of time had become centre of a large number of activities in the State. He had put the Punjab University on the world map of science. Sir Henry Craik, the then Governor of Punjab, at the Northern India Chamber of Commerce on 13 April 1940 said: "There is every reason to suppose that the war will give the immense fillip to Indian industry. There will be a double stimulus. The great demand for industrial products created by the war will be a direct incentive to existing industries, while the difficulty of obtaining many of the articles we imported before will stimulate the search for substitutes or for ways and means of producing them here. We are thus presented with unrivalled opportunity of increasing Industrial activity. And in order to promote and co-ordinate expansion and to facilitate the exploration of fresh fields of development the Central Government have just set up a Board of Scientific and Industrial Research on which a number of distinguished scientists and industrialists of this country have consented to serve. I believe that the establishment of the new organisation will prove to be an important landmark in the history of India's industrial development, and I am sure that everybody here would agree with me in congratulating the Central Government on having secured the Services of Dr. Bhatnagar as a member of the Board and as Director of Scientific and Industrial Research As Chancellor of our provincial University, of which he was so

distinguished an ornament, I deeply regret his transfer to another sphere. But that sphere is of such importance to the country as a whole, that I did not feel I could object when the request was made for his services." Bhatnagar left Lahore by Frontier Mail. A large number of people gathered to see him off. Among the notable persons who came to the railway station were: Justice Baksi Tek Chand, Raja Narendranath, the Vice Chancellor of the University K. B. Mian Afzal Hussain, Dr. L. C. Jain, Prof. Ruchi Ram Sahni, Prof. G.D. Sondhi and Dewan Anand Kumar.

After the completion of the Second World War, there was a move by the Punjab Government to bring back Bhatnagar to Punjab as the Vice chancellor of the Punjab University. However, this attempt did not succeed as the Government of India was not in a position to afford to lose valuable services of Bhatnagar.

On the joining of Bhatnagar as Director of Scientific and Industrial Research, Government of India, the Industrial Intelligence and Research Bureau were suspended. The staff of the Bureau was placed under the control of the new Department. Bhatnagar's first office at Delhi as Director Industrial Research was at the Palace of the Nizam of Hyderabad located near the India Gate. Soon he moved to Simla, Where he stayed until he again moved to Kolkata (then Calcutta) on June 20, 1940. The arrangement was that Bhatnagar would remain eight months at Kolkata and a small laboratory was established in the Government Test House. Bhatnagar with the help of his Steel Research Scholars started working in real earnest. Functioning under the able leadership of Bhatnagar, the BSIR in the very first year led not only to a number of war-related problems being solved, but also prepared the background for the utilization of laboratory-research results by the industry. The laboratories of the Board of Scientific and Industrial Research were called Central Laboratories. The Board's laboratories later shifted from Kolkata to Delhi University in Delhi in 1942 and they remained there till 1947.

As there were no established research laboratories for working on war-related problems, the Board of Scientific and Industrial Research in its second meeting in June 1940 at Simla approved the formation of a number of research committees to pursue schemes submitted by universities and institutions. Each Research Committee was expected to monitor the progress of a particular scheme in operation, formulate co-ordinated proposals for further schemes in the concerned field. In general, the Research Committees were to assist the Board in ensuring that the grants made to them were carefully utilized so that best possible results could be obtained. The Director of Scientific and Industrial Research was an ex-officio member of all the Research Committees.

The BSIR, in spite of a very limited budget at its disposal, was able to work out a number of processes at the laboratory level for industrial utilization. In early 1941, the Government set up an Industrial Research Utilisation Committee (IRUC). It was the result of the effort made by Bhatnagar. On the recommendation of the IRUC, the Government agreed to establish a separate fund out of the royalty receive from the industry for further investment in industrial research. The BSIR, within a short span of its existence, was able to demonstrate the need for systematic organisation of scientific and industrial research under the aegis of the Government of India. It was obvious from the functioning of the BSIR's Research Committees that if adequate financial support is given, the results of the industrial research undertaken by the Committees can make significant contribution towards the development of the country. Ramaswamy Mudaliar had realised the long-term implications of industrial research. He thus moved a resolution in the Central Assembly for establishing an Industrial Research Fund for promotion industrial research in the country. It was proposed in the resolution that a provision of Rs. 10 million per year should be kept for a period of five years. The Central Assembly accepted the resolution at its Session on 14 November 1941. To administer this Fund, the Council of Scientific and Industrial Research (CSIR) was established under the provisions of the Registration of Societies

Act XXI of 1860. The CSIR came into operation on 28th September 1942. Its functions, as laid down in its constitutions, were:

- The promotion, guidance and co-ordination of scientific and industrial research in India including the institution and the financing of specific researches;
- The establishment or development and assistance to special institutions or departments of existing institutions for specific studies of problems affecting particular industries;
- The establishment and award of research studentships and fellowships; the utilization of the results of researches conducted under the auspices of the Council towards the development of industries in the country and the payment of a share of royalties arising out of the development of the results of researchers to those who are considered as having contributed towards the pursuing of such researches;
- The establishment, maintenance and management of laboratories, workshops, institutes and organisations to further scientific and industrial research and to utilize and exploit any discovery or invention likely to be of use of India industries;
- The collection and dissemination of information in regard not only to research but also to industrial matters generally;
- The publication of scientific papers and a journal of industrial research and development; and
- Any other activities to promote generally the objects of the resolution.

A Governing Body was constituted for monitoring and reviewing the activities of the CSIR. The Research Committees played an important role in shaping the activities of the CSIR. By 1945, twenty Research committees were constituted.

1. The Glass and Refractories Committee was constituted on July 9, 1940 under the Chairmanship of Dr. A. Nadel, who was succeeded by M.G. Bhagat.
2. The Electro-Chemical Industries Committee was constituted on December 01, 1943 under the chairmanship of Sir J.C.

Ghosh. This Committee amalgamated the Graphite and Electrode Committee constituted on July 09, 1940.

3. The Industrial Fermentation Committee was constituted on July 09, 1945 under the Chairmanship of B.C. Guha who was later succeeded by Dr. Basir Ahmad.
4. The Dye-staffs Committee was constituted on July 09, 1940 with Sir Ardeshir Dalal as its Chairman.
5. The Fuel Research Committee was constituted on July 09, 1940 under the chairmanship of Dr. H. K. Sen, who later succeeded by C. S. Fox.
6. The Vegetable Oil Committee was constituted on July 09, 1940. Its first Chairman was Shanti Swarup Bhatnagar himself and who was later succeeded by K S Krishnan.
7. The Cellulose Research Committee was constituted on July 09, 1940 under the Chairmanship of Dr. Nazir Ahmad.
8. The Heavy Chemicals (Including Fertilisers and Salts) Committee was constituted on July 09, 1940 under the chairmanship of Dr. C. S. Fox, who was later succeeded by Dr. H. K. Sen.
9. The Drugs Committee was constituted on July 09, 1940 under the Chairmanship of R. N. Chopra, who was later succeeded by Col. S. L. Bhatia.
10. The Plastics Committee chaired By S. S. Bhatnagar was constituted on July 09, 1940. After two years Bhatnagar was succeeded by Sir J. C. Ghosh as the Chairman of the Committee.
11. The Sulphur Committee was constituted on July 09, 1940. Its first Chairman was Bhatnagar.
12. The Essential Oils Committee was constituted on July 09, 1940 with P. A. Narielwala as its Chairman.
13. The Metals Committee was constituted on November 16, 1940 under the Chairmanship of J. J. Ghandy.

14. The Internal Combustion Engines Committee was constituted on February 21, 1941 under the Chairmanship of J. C. Mahindra.
15. The Distillation and other Chemical Plants Committee was constituted on February 28, 1941 under the Chairmanship of Kapilram Vakil, who was later succeeded by S. S. Bhatnagar.
16. The Applied Physics Committee was constituted on July 09, 1940 under the Chairmanship of Dr. Nazir Ahmad.
17. The Radio Research Committee was constituted on June 01, 1942 under the Chairmanship of Professor S. K. Mitra.
18. The Statistics, Standards and Quality Control Committee was constituted on December 01, 1943 under the chairmanship of Dr. P. C. Mahalanobis.
19. The Leather Research Committee was constituted on December 01, 1943 under the Chairmanship of Rai Bhadur. B. M. Das.
20. The Building Materials Committee was constituted on December 01, 1943 under the Chairmanship of T. S. Malik

Bhatnagar in a radio talk entitled "Scientists at Work" broadcast from Delhi on September 13, 1943 gave an account of the results of the Industrial Research since April 1940. He said: "During the period of little more than three years, since the Board of Scientific and Industrial Research had been founded, among the many fields of investigations in which the researchers had been engaged were those of metal, plastics from natural sources, chemicals, drugs, substitute for shortages, vegetable oils and other fats and waxes. Industrial, agricultural, and other wastes have been shown to be capable of commercial utilization and salvage operations in some cases have been encouraged by our findings.

It has been estimated that goods to the value of more than four and a half crores of rupees have already been supplied as a result of the new processes and products that have been developed on the results of research work initiated by the Board. These figures

do not include many production figures which are not yet available, nor they include such items as sulphur, anti-mosquito cream, etc., in dealing with which the Board has played the role of a catalyst.

i) Shellac
ii) Modifications of lac for anti-gas vanishes
iii) Modified lac for seaming varnishes
iv) Oil plastics
v) Plastics from coffee beans
vi) Plastic from seed cakes
vii) Resins from other indigenous plants

Secondly, substitutes for paraflow, cork, window glass, white lead, zinc oxide, for good wood, for galvanized sheeting, for usual plasticisers, for enamels, for tung-oil, for fibre products, for cellophane type of wrapping papers, for kerosene as illuminant and also substitute for rubber. Some of these substitutes are now in large scale use. The Council publishes a quarterly journal, soon to become a monthly and a Dictionary of Raw Materials was being compiled dealing full with extent, scope and availability of all raw materials in the country."

Bhatnagar wanted to extend the scope of the CSIR by establishing a chain of national laboratories in the country under its command. The Governing Body of CSIR approved the proposal of Bhatnagar to establish five national laboratories. Bhartnagar in his address to Opening Ceremony of the National Physical Laboratory in January 1947 said: "The idea of establishing a twin -set of laboratories, the National Physical Laboratory (NPL) and the National Chemical Laboratory (NCL), was accepted in the beginning of 1943 by the then formed CSIR. Soon after, the idea was widened in scope and the Council approached the Government of India for the grant of a crore of rupees for the post-war establishment of five-National Laboratories, the three additional ones being, a National Metallurgical Laboratory, a Central Glass and Ceramic Research Institute and a Fuel Research Institute. Planning

Committees consisting of some of the best available scientific and technical talents in the country were set up to prepare broad plans for the work, functions and organisation of each of these laborations.

It is necessary to stress here the nature of the National Laboratiories. These Laboratories do not intend to support but to supplement the work of individual or collective industrial concerns in respect of research. They undertake work of the kind that does not come ordinarily under the scope of industries. Since they are able to command resources wider than the industries can, the laboratories can employ more talent and try alternative approaches to problems simultaneously. Problems which bear wider social aspects than an industry could be concerned which become subject of state scientific research. Moreover, the advice that state research can give will be not-partisan. Industry can hardly undertake work of a purely exploratory nature. So the function of these laboratories is both complementary and independent."

During Bhatnagar's lifetime 14 national laboratories were operational, acquired or had their foundation stone laid. They were:

1. National Chemical Laboratory (NCL), Pune
2. National Physical Laboratory (NPL), New Delhi
3. Central Fuel Research Institute (CFRI), Dhanbad
4. Central Glass and Ceramic Research Institute (CGCRI), Kolkata
5. Central Food Technological Research Institute (CFTRI), Mysore
6. National Metallurgical Laboratory (NML), Jamshedpur
7. Central Drug Research Institute (CDRI), Lucknow
8. Central Road Research Institute (CRRI), Roorkee
9. Central Electrochemical Research Institute (CERI), Karaikudi
10. Central Leather Research Institute (CLRI), Chennai
11. Central Building Research Institute (CBRI), New Delhi

12. Central Salt Research Institute (CSRI), Bhabnagar
13. Central Electronics Engineering Research Institute (CEERI), Pilani
14. National Botanical Research Institute (NBRI), Lucknow

In addition Publications and Information Directorate and Indian National Scientific Documentation Centre (INSDOC) were established in New Delhi. The INSDOC was set up in New Delhi in 1952 with technical assistance from UNESCO, to provide full range of documentation service to the scientists and technologists in the country.

The first eleven laboratories listed above are often called the Bhatnagar 11. These laboratories were operational by 1951. Some of these laboratories started functioning in the existing buildings making available to the CSIR and some created their own buildings. Initially these 11 laboratories were planned. Thus on the occasion of opening the Central Salt Research Institute (later renamed as Central Salt and Marine Chemical Research Institute) in 1954, Bhatnagar said; "The CSRI, which the Prime Minister will open shortly forms the twelfth link in the chain of national laboratories which are directly sponsored by the CSIR in different parts of the country. By setting up of this institute, we are entering the second phase of our national activity; the first phase of the plan involved setting up of only eleven national laboratories."

We will briefly describe here the objectives with which the first fourteen laboratories were started. However, it should be noted that by no means these descriptions are complete.

## 1. National Chemical Laboratory

Bhatnagar in his capacity as Director, Scientific and Industrial research had proposed the desirability of establishing a National Chemical Laboratory (and also a National Physical Laboratory) in September 1941. The Board of Scientific and Industrial Research at their 10$^{th}$ meeting held on July 12, 1943 recommended the

formation of a planning committee to examine the question of site, equipment, staff and expenses. The recommendation was approved by the Governing Body of the Council of Scientific and Industrial Research at their 4th meeting held on July 14, 1943. The NCL Planning Committee was set up under the Chairmanship of Sir Ardeshir Dalal. In June 1944, Dr. Bashir Ahmad was appointed Assistant Director, Planning and Secretary to the NCL Planning Committee. In October 1944, Dr. John Mathai replaced Sir Ardeshir Dalal as Chairman of the Planning Committee when the latter joined as Member for Planning and Development, Government of India. Other members of the Planning Committee were: Shanti Swarup Bhatnagar, Jnan Chandra Ghosh, J. N. Mukherjee, K. Venkataraman, M. Qureshi and M. D. Parekh. The Tatas donated Rs. 8,30,000 for the establishment of the NCL. The Government of India allocated Rs. 25,00,000 out of the sum of Rs. 1,00,00,000 for the development of national laboratories for NCL. The foundation stone of the National Chemical Laboratory at Pune was laid on April 06, 1947. At the time of opening of the NCL, it was planned to have the following seven divisions:

i. Inorganic Chemistry including Analytical chemistry
ii. Physical Chemistry including Electro-chemistry
iii. Chemistry of Plastics and High Polymers
iv. Organic Chemistry
v. Biochemistry including Biological Evaluation
vi. Chemical Engineering
vii. Survey and Information.

For successful solution of industrial chemical problems, it was decided that the NCL will not remain confined to chemistry alone but its activities would also cover physics, mineralogy and biology in so far as they related to chemical problems and chemical utilization of national resources.

In his address on the occasion of opening of the NCL on January 03, 1950, Bhatnagar said: "One of the most important

functions of the NCL will be to bridge the gulf between science and its application. It will be the link between the universities and other scientific institutes in the country and industry. It will work out means for the application of scientific knowledge to practical problems, of human welfare. Developmental work involves work by team of scientists of high quality and originality and requires expenditure of money which at the outset may seem unproductive. The NCL is being equipped and organised to meet the need for such development work. The laboratory will try to improve old processes in the light of new scientific knowledge, and to discover new processes. The development of new processes will be carried to the pilot plant stage in the laboratory. This is what we have not had in India with the result that many processes have gone by the way, for it is only when a process has been taken to the pilot plant stage that industry gets interested in adopting it for large scale production. After a successful process has been passed on to industry, the NCL will continue to keep in touch with industry and difficulties or problems that may arise in the large scale manufacture of the product will be studied and solved in the laboratory. In addition to the processes developed in the National Chemical laboratories, other problems of industry which fall within the scope of the laboratory will be taken up. The scientists of the laboratory will on their own intiative investigate materials and technological processes to help industrialization. In short the National Laboratory will be a living and vital link with the universities, scientific institutes and industry."

The first Director of the NCL was Prof. James William McBain, a distinguished physical chemist and a Fellow of the Royal Society of London.

## 2. National Physical Laboratory

The Foundation Stone of the National Physical Laboratory was laid in January 1947 and it was opened on May 21, 1950. The Planning Committee for the National Physical Laboratory included Shanti Swarup Bhatnagar, Meghnad Saha, Nazir Ahmad, K.S.

Krishnan, G.R. Paranjpe, Homi Jehangir Bhabha, Wali Mohammad, D.M. Bose, Rafi Mohammed Chaudhry, and M.N. Sengupta, K.N. Mathur, then working at the Lucknow University, was appointed as Assistant Director for planning and Secretary to the Planning Committee. It was decided to locate the National Physical Laboratory at Delhi. Explaining why it was decided to locate the Laboratory at Delhi, Bhatnagar in his address made on the occasion of the Foundation Stone Laying ceremony in January 1947, said: "The question of location of the NPL was thrashed out threadbare and the (Planning) Committee made out an overwhelming case in favour of locating the Laboratory at the headquarters of the Central Government. In any new constitution the importance of contact between science and state will even be greater. Delhi, besides being the seat of a young and hence very virile university, is in addition the headquarters of a number of scientific departments of the Government of India like the Meteorological Department, the Agricultural Department, the Medical Department, the Royal Indian Air Force, the Scientific Section of the G.H.Q, the All India Radio, the Railway Board and others. We are particularly fortunate in the present site as we are close neighbours of an institution which has played no inconsiderable part in India's agricultural development I mean the Agricultural Research Institute right opposite us. The Institute has one of the best libraries on the biological sciences and between NPL and the Institute, we shall have the most complete scientific library in India which we hope will form the nucleus of a central Information Service for all scientific workers in India,"

At the time of planning the Laboratory, the following nine divisions were envisioned to carry out the work of the laboratory.

1. Weights and Measures
2. Applied Mechanics and Materials
3. Heat and Power
4. Optics
5. Electricity

6. Electronics and Sound
7. Building and Housing Research
8. Hydraulic Research
9. Analytical Chemistry

By the time the Laboratory was opened in 1950, a tenth division on industrial physics was added.

Commenting on the scope and functions of the NPL, Bhatnagar said: "In the main, the Laboratory's foremost function will be the maintenance of fundamental and derived standards, and the undertaking of research with a view to achieve greater and greater accuracy in the measurement of those standards. At present there is no well-equipped laboratory in India which can undertake standards work. One or two laboratories in India possess yard and metre bars which were at one time standardized by the National Physical Laboratory at Teddington. The Mint at Bombay have in their possession certain standard weights certified by the National Physical Laboratory of England. But in neither case any systematic organisation exists to undertake regularly inter-comparison between their standards and of those of the other countries, which is the accepted method of all stardards laboratories... Apart from the work of standardization the laboratory will be called upon to undertake considerable amount of research work which is expected to go a long way towards developing industry in this country. Physical science is taking long and fast strides. New discoveries in the fundamental sciences are opening up vast possibilities of industrial application both by way of improving old processes and by introducing new ones. The NPL will be concerned with maintaining constant research work to fulfill this purpose. For the same reason they will maintain a close liaison with Industry. Investigation of raw materials of the country with a view to adopt them to the requirements of the industry will be a correlative work which the laboratory will undertake."

The first Director of the National Physical Laboratory was K.S. Krishnan. Commenting on Krishnan's selection Bhatnagar said:

"India has distinguished herself in physics and has provided a majority of Indian Fellows of the Royal Society and a Nobel Laureate. I was certain that we will not have to go out of the country to get an expert to guide the destinies of this Laboratory... Sir K.S. Krishnan's fame as a Physicist transcends the limits of this country. In Indian physics the most sensational discovery for which Sir C.V. Raman was awarded the Nobel Prize is the Raman Effect. As we all know, our distinguished Director was most intimately associated with this discovery. He is a scholar of eminence and yet his genius does not originate in mental eccentricities, its poise and depth rest on the solid foundation of innate culture and a balance without which cooperative effort in research is an impossibility."

The establishment of the National Physical Laboratory drew international acclaim. In a message sent to Bhatnagar (in January 1950) on the occasion of the opening of the National Physical Laboratory, Sir Robert Robinson, then the President of the Royal Society of London, wrote: "We cannot forbear from adding a personal message of congratulations to Sir Shanti Bhatnagar who is so well known to us and whose practical initiative and capacity for action has made possible the realization of his dreams."

In the March 1952 issue of *Physics Today,* Dr. L.S. Curtiss, wrote: "Perhaps the most notable example of the efforts to improve the position of physics in India which came to my attention is the New National Physical Laboratory at Delhi. It is easy to predict that this laboratory will, when in full operation, contribute handsomely to the progress of physics not only for the benefit of India but the rest of the world as well. Even in its present incomplete state the building in size and attention to detail represents a structure that would form a prized acquisition by any Government. In addition it seems to stand as a symbol of the kind of progress to be expected in a country which has already made valuable contribution to the advancement of physics."

## 3. Central Fuel Research Institute

Following the recommendation of Bhatanager, as Director of the

Board of the Scientific and Industrial Research, a Fuel Research Committee was constituted by the Government of India on July 9, 1940. The first Chairman of the Committee was Dr. H.K. Sen, then Director of Industries, the Government of Bihar. In its first meeting (22-23 August 1940), the Committee "resolved that the ultimate aim should be establishment of a Central Fuel Research Station for India". The Fuel Research Committee was reconstituted in December 1940. A sub-committee of the Board of Scientific and Industrial Research in its meeting on January 8, 1941 recommended the establishment of a Central Fuel Research Institute for undertaking the following:

i. Chemical and physical survey of Indian coal.
ii. Processing and preparing coal with special reference to metallurgical coke.
iii. Low temperature carbonization.

The Governing Body of the Council of Scientific and Industrial Research in its meeting on December 1, 1943 allocated Rs. 3 lakhs for the establishment of the Fuel Research Station. The money sanctioned could not be spent for the first two years and the grant was renewed every time. Bhatnagar on his visit to the United Kingdom in November 1944 selected Dr. A. Lahiri, who was then in United Kingdom, for the post of Assistant Director for planning, the post which was advertised. Dr. Lahiri joined the post in June 1945. In the mean time the Fuel Research Committee was reconstituted in June 1945 and it was enlarged in January 1946. Dr. J.W. Whitaker, then Principal, Technical College, Huddersfield, was appointed as the first Director of the Fuel Research Institute. The Institute was planned to have the following six technical divisions:

i. Physical and chemical survey of coal resources including analytical section.
ii. Carbonisation and by-products including colloids and rheology sections and liquid fuels and oils.
iii. Chemistry division including hydrogenation, synthesis, plastics and coal preparation section.

iv. Physics division including pyrometry, calorimetry, X-ray and spectroscopy.

v. Gaseous fuels division including wood fuels.

vi. Engineering division.

In addition to the technical divisions, the Institute was proposed to have two other divisions—Library and Intelligence and Administration. Pt. Jawaharlal Nehru, on the occasion of the opening of the Central Fuel Research Institute, said: "In the course of less than four months we have put up, declared open, or are going to declare open, three National Laboratories. I suppose before this year is out some more National Laboratories will also be started. This is a great venture testifying to the faith which our scientists and our Government, I hope have in science... If we look at science in the fine way, and if we think of these research institutes and laboratories in the fundamental sense, then they are something more than institutes for finding out little ways of improving things of how this or that should be done. Of course, our laboratories help in such ways, but they have also gradually affect our minds, the minds not only of those who work in them, for example, the young men and the young women who might work here, but the minds of others too..."

At present Central Fuel Research Institute is working in the areas: resource quality assessment including geology and petrography of coal; preparation of coal—coal washing, demineralization, briquetting, pelletization and flocculation; technology for direct use of coal—combustion specially fluid-bed combustion, and carbon artefacts for electro-thermal and chemical industries; conversion of coal—carbonisation (high and low temperature, fluid-bed), gasification, oxidation, solvent extraction, production of synthetic fuels and chemicals from coal; product improvement and valorization, including recovery and purification of coal-tar chemicals and utilization of industrial; and agricultural wastes and process development and scale-up studies.

## 4. Central Glass and Ceramics Research Institute

The idea of establishing a Central Glass and Ceramic Research Institute was first proposed by Bhatnagar in 1942 and in the same year the proposal was accepted by the Council of Scientific and Industrial Research. Explaining the necessity of such an Institution, Bhatnagar in his address made at the opening ceremony of the institute, said: "The CSIR realized that Glass and Ceramic Industries of India must be scientifically developed if they have to play the role they must, in the onward march of progress and achievement which, in our conviction, is India's destiny. Every year we import nearly 2 crores rupees worth of glassware and 7 lakhs rupees worth of china-ware and porcelain. India manufactures 45 crores rupees worth of glass and 1.31 crores rupees worth of china-ware. As India marches along its progressive goal, the demand for these articles is bound to increase considerably and these industries therefore afford a fertile field for development through the applications in which these items find imporant used for decorative, protective, utility and other purposes."

The objective of the CGCRI is scientific and industrial/applied reseach of national importance in the field of glass, ceramics, refractories, various enamels and composites. The activities of the Institute are concerned with:

i. Development of technologies relevant to the country's social, defence, economic and industrial needs.

ii. Evaluation and optimum utilization of the country's resources of related raw materials.

iii. Attainment of technological competence and self-reliance in the field of special glass and ceramic materials.

iv. Absorption, adaptation and updating of imported technologies relevant to the country's social, economic and industrial needs in related fields.

v. Carrying out projects sponsored by public/private enterprises and rendering technical assistance to industry in improving

quality, productivity, design and performances of furnaces etc.

vi. Basic research in related fields necessary for furthering applied research and for building up scientific and technological capability.

vii. Rendering technical advisory services like information, consultancy, testing etc., to industry and government departments in developing glass and ceramic industry.

## 5. Central Food Technological Research Institute, Mysore

The principal objective of the Institute is to stimulate the growth and productivity of India's food industry through the most efficient utilization of India's food resources. To realize its aims, the Institute undertakes wide range of activities covering the following areas:

i. Development of food products and processes for optimal utilization of the country's agricultural produce to meet the food needs.

ii. Development of nutritious food for vulnerable groups of population.

iii. Development of food processing machinery for indigenous industry.

iv. Development packaging techniques for food materials and processed items.

v. Utilisation of residual waste/by-products of the food industry.

vi. Development of export-oriented value added products.

vii. Development of integrated systems for post-harvest handling of the agricultural produce.

The CFTRI serves as an active centre for development of human resources for the food industry and government agencies concerned with food. It runs a two-year postgraduate course to train students from developing countries for postgraduate degree

in food technology of the University of Mysore and also short courses on different topics for professionals from industry and government agencies.

Bhatnagar in his address on the occasion of the opening ceremony of the CFTRI, said: "Today's inauguration of this institute is the first step which the Government of India have taken to solve the food problem by the technological as distinguished from the purely biological methods... The principal object of this institute is to carry out technological research on foods and suggest methods so that food supplies could be kept longer and more usefully utilized. As every preserved or processed food is likely to change its nutritional and digestive qualities and palatability, biochemical and nutritional investigations on such products, right on the spot, will be necessary. Hence these sections have been provided in the institute."

## 6. National Metallurgical Laboratory

At the suggestion of Bhatnagar, the Board of Scientific and Industrial Research set up a Metals Committee in the year 1940 under the chairmanship of Sir J.J. Ghandy. In the very first meeting of the Metals Committee it was decided that to ensure the progress and expansion of the country's metallurigal industry a central organization in the form of a National Metallurgical Laboratory was essential. Subsequently a National Metallurgical Laboratory Planning Committee was set up to submit a detailed plan for establishing such a laboratoy. The Committee consisted of Sir J.J. Ghandy, Sir Cyril Fox, Mr. E.V. Parkinson, Mr. R.A. MacGrager, Mr. N. Hackney, Dr. Dayaswarup and Dr. S.S. Bhatnagar. The Foundation Stone laying ceremony of the NML took place on November 21, 1946 and the institute was opened November 26, 1950. The Laboratory is located in Jamshedpur. To explain why the laboratory was located in Jamshedpur, Bhatnagar said: "Jamshedpur has been chosen for the location of the laboratory in consideration of numerous facilities offered by this great place. The foremost of these has been the consideration that in the application of fundamental research to metallurigal industry close contact between the research workers

and the industry itself is essential, Jamshedpur is the heart of Indian metallurgical industry and affords excellent facilities for the study of practical operating problems at the Works of the Tata Iron and Steel Co., the Tatanagar Foundries, the Jamshedpur Engineering and Machine Manufacturing Co., the Tinplate Co. of India, The Indian Steel and Wire Products and the Indian Cable Co. The Indian Copper Corporation is close by, while most of the engineering industries are centred around Calcutta and the National Fuels Research Institute sponsored by the CSIR is close by at Dhanbad."

The objective of the Laboratory was to undertake research and development work in various disciplines of metallurgy and allied fields. To quote Bhatnagar: "The NML, when completed, will cover all aspects of metallurgical research, both fundamental and applied and will also carry out research work on ores, minerals and refractories. The preparation of minerals and ores and the smelting of the latter are so definitely a part of the development of the country's metallurgical industry that facilities, complete with pilot plant facilities for mineral research will be provided in the NML. As the metallurgical industry is one of the largest consumers of refractories, research in refractories will also be associated with that on metallurgy in the NML together metallurgical furnace design. Work on refractories would be greatly facilitated by the presence of minerals research section with its specialized laboratory and pilot plant equipment.

In the final plans of the NML, provision has been made for administration including statistics, chemical analysis, physical chemistry, physics, preparation and smelting of metallic ores, the smelting, heat treatment and working of metals and alloys, the electrochemistry of metals and research on refractories together with facilities for the application of research result to commercial operating conditions and for the study of such conditions as they affect the quality of the products and the efficiency and economy of commercial production. Special mention must be made here that research on non-ferrous primary metals such as copper, aluminium, manganese, zinc, titanium, beryllium, etc., for which we in this

country have got cheap and abundant raw materials, will form an important part of the activities of the NML... In the field of non-ferrous alloys also such as aluminium-titanium alloys, aluminium-magnesium alloys, etc. research will be carried out in the NML."

## 7. Central Drug Research Institute

The CDRI was opened on February 17, 1951. It was located at Lucknow. The idea for the establishment of a national laboratory totally devoted to drug research was first proposed by Dr. B. Mukerji, then Director, Biomedical Standardisation Laboratory, Calcutta (now Kolkata). The proposal was first made in his presidential Address to the Physiological Section to the Indian Science Congress at Nagpur in 1945. In 1947, a comprehensive scheme for establishing such a laboratory jointly prepared by Dr. Mukerji (Who by then had become Director of Central Drugs Laboratory, Calcutta) and Dr. Jivraj N. Mehta, then Director-General, Medical and Health Services, Government of India was submitted to Bhatnagar. The proposal was examined by the Pharmaceuticals and Drugs Research Committee and it recommended the establishment of the Central Drug Research Institute. The recommendation of the Committee was accepted by the BSIR at its nineteenth meeting on August 24, 1947. As a first step towards the establishment of the Laboratory, a Planning Committee under the Chairmanship of Dr. Mehta was constituted in February 1948. Dr. D.L. Shrivastava was appointed as Assistant Director, Planning in September 1948. The Planning Committee had four options for the location of the laboratory—the Ramsay Hospital building in Nainital, Allahabad Club building and Chattar Manzil in Lucknow offered by the UP Government and Snowdon in Simla offered by the Himachal Pradesh Government. The Committee opted for Lucknow and which was finally approved by Pandit Jawaharlal Nehru, the Prime Minister of India, in 1949.

CDRI, one of the first and few laboratories that were established in India right after its independence, was formally inaugurated on 17th Feb 1951 by the then Prime Minister of India, Pandit Jawaharlal

Nehru. Its mission is to strengthen and advance the field of drug research in India.

The objectives of the Institute are:

- Development of new drugs and diagnostics.
- Cellular and molecular studies to understand disease processes and reproductive physiology.
- Development of contraceptive agents and devices.
- Systematic evaluation of medicinal properties of natural products.
- Development of technology for drugs, intermediates and biologicals.
- Dissemination of information in the field of drug research, development and production.
- Consultancy and development of technical manpower.

CDRI is a multidisciplinary laboratory with divisions like Biochemistry, Biopolymers, Botany, Clinical & Experimental Medicine, Endocrinology, Fermentation technology, Medical Mycology, Medical Chemistry, Membrane Biology, Microbiology, Parasitology, Pharmaceutics, Pharma-kinetics & Metabolism, Pharmacology, process Development and Toxicology.

The first Director of the CDRI was Sir Edward Mellanby.

## 8. Central Road Research Institute

The history of the establishment of the Central Road Research Institute (CRRI) can be narrated in a few words. The Indian Roads Congress in their meeting held in Nagpur in December 1943, recommended the setting up of a Road Research Institute. A keen controversy ensued as to whether the proposed institute should be attached to the Transport Department or the CSIR. However, the War Transport Department submitted a note on the subject to the Industrial Research Planning Committee of the Council presided over by Shri Shanmukham Chetty in 1944. After

a careful consideration, the Committee recommended the inclusion of CRRI as one in the chain of national laboratories. A specific recommendation for the establishment of the institute was accepted in principle by the Council at its meeting on the 21st September 1945 and a Road Research Advisory Committee was appointed to work out the details.

The CRRI was established in the year 1948 with the mission to deliver high quality and globally acceptable research as well as consultancy services to the profession in the major areas of road and road transportation technology. Pandit Jawaharlal Nehru on the occasion of the opening of the Central Road Research Institute said: "In everything that we do we always come up against this big problem, how to get so many things done that we want to do in the least possible time. There are obvious limitations of finance, trained personnel and so many other things. You cannot simply waive aside the limitations and say, 'we will do it.' You must be practical, you cannot be just airy. Nevertheless I think there can be ways and means of getting over many of these limitations. That is why we think about most of the time, whether it is in the Planning Commission or elsewhere. We come up against rigid outlooks. We are conservative in the sense that we do not like taking a new step because we are used to a certain routine or rut. Yet, what is absolutely necessary is some new step. You cannot meet a new situation in an old way that created the new situation. So we should realize that we have got to do things rapidly and quickly and is not quite enough to say that there are limitations which prevent our going fast... But as I have wondered about this country, I have come to the conclusion that one thing to which we must give top priority is roads–roads of all kinds, not only up-to-date bituminised or cement-roads but roads of any kind, to open up vast areas of this country which are closed up to-day and which we cannot reach unless you walk up or ride."

The first Director of the CRRI was Dr. Ernst Zipkel of Zurich. Today, the CRRI is an ISO Certified Institution. The broad areas of the research activities undertaken by the Institute are: (I)

Pavement Engineering (ii) Geotechnical Engineering (iii) Bridge Engineering (iv) Traffic and Transportation Engineering including Safety and Enviroment (v) Highway Planning and Management (vi) Instrumentation for highways and bridges.

## 9. Central Electrochemical Research Institute

The need for a specialized research Institute for electro-chemical research was first highlighted by Sir R.K. Shanmukham Chetty, then Chairman of the Industrial Research Planning Committee. The Electro-Chemical Industries Research Committee headed by Dr. J.C. Ghosh was also convinced of the necessity of such a central laboratory in the field of electro-mechanical research. For establishing the Central Electrochemical Research Institute, Dr. Rm. Alagappa Chettiar made a generous gift of 300 acres of land on his estate at Karaikudi and Rs. 15 lakhs towards capital expenditure. Initially Bhatnagar did not like the location for CERI. He said so at the Foundation Laying Ceremony of the Institute on July 25,1948. Bhatnagar said: "Most of you are aware that I was skeptical of the wisdom in our agreeable to having Karaikudi is the proper venue for the location of the National Electrochemical Research Institute. Its distance from industry and universities, the scarcity of water, the nature of soil and the absence of large trees and green foliage were factors which did not allow me to agree to the suggestion made by Alagappa Chettiar and the inhabitants of the place that Karaikudi should be chosen for this National laboratory. It is the persistence of our great donor, the support and keen desire of the Government of Madras and the Hon'ble Minister for Industry in Madras particularly, and the love of country side which the Prime Minister of India possesses, so abundantly in his heart, that ultimately succeeded in my being persuaded to waive my objections to this site."

Elaborating the scope and functions of the CERI, Bhatnagar said: "Electro-chemical processes have completely revolutionized the production certain primary products such as chlorine, sodium,

hydrogen peroxide and aluminium and permitted the development of new secondary industries utilizing cheaper raw materials. The cost of electrical power is usually the desideratum in these industries. While per capita consumption of electric power in India, at the present time, is admittedly low compared to that in U.S.A, U.K. and U.S.S.R, it may be expected that before long it will rise several-fold, thanks to the bold policy and drive of the Indian Government in the implementation of vast hydro-electric power projects all over the country. Coupled with this the availability of key raw materials and cheap labour will doubtless lead to a vigorous and multi-directional growth of our electro-chemical industries. The products of these industries are of considerable strategic and economic importance. Research in electro-chemistry is a necessary preliminary to the expansion of electro-chemical industries.... To start with, the Electro-chemical Research Institute will have two main divisions, the electrolytic and electrothermic. In addition, there will be ancillary laboratories and workshop consisting of, among others, an analytical section, a chemical engineering section. The investigations will cover problems relating to production of heavy water, other inorganic substances and organic chemicals by electro-chemical methods."

## 10. Central Leather Research Institute

In 1944, Bhatnagar set up the Leather Research Committee of the CSIR. This was the first attempt in the country to seriously examine the possibilities of planned and co-ordinated scientific research in leather manufacture. On the recommendation of the Leather Research Committee, the CSIR started financing leather research on planned basis in several centers including a yearly grant of Rs. 60000 to the Department of Leather Technology of the Madras University and a grant for a five-year project at the Bengal Tanning Institute, Kolkata. The Committee recommended that it was essential to establish a Central Leather Research Institute, if India was to develop the leather industry on the line of leather industries of Europe and America.

On the occasion of the Foundation Laying Ceremony of the Institute (April 24, 1948). Bhatnagar said: "The idea of having this Institute at Madras was conceived as far back as in 1945, but for various reasons beyond our control it could not take a concrete shape earlier. In recognition of the great importance of leather technology the CSIR has been making a block grant of Rs. 60,000 a year to the University of Madras, so that they could run a Centre of leather research and technology in the University, which may ultimately develop into a full-fledged Research Association Laboratory. In a national endeavour of this nature, it is through the willing co-operation of one and all that success could be achieved. In our effort to establish this institute, we have had the sympathy and support of the National Government at the Centre, the Government of Madras, the commercial community of India interested in leather trade and industry at the University of Madras. I wish to take this opportunity for thanking Shri C. Rajagopalachari, Shri T. Prakasam, Shri O.P. Ramaswamy Reddiar and Shri A Lakshmanaswamy Muddaliar, for the invaluable help they have given us. The government of Madras have promised to place at our disposal free of cost a site measuring about 200 acres and also to bear a part of the recurring expenditure of the proposed institute. The industry has also promised to make contributions towards capital as well as recurring expenditure but the brunt of the burden will be borne by the Central Government through the CSIR."

## 11. Central Building Research Institute

The proposal for establishing a Central Building Research Institute was approved by the Governing Body of CSIR in July 1949. The Building Research Committee, constituted for planning for institute, opted for Roorkee as the location for the Central Building Research Institute. The decision of the committee was influenced by the following facts:

i. The country's premier engineering institution, Thomas College of Engineering was situated at Roorkee and the Government of UP had taken a decision to covert this institution into an

engineering university (this is how Roorkee University came into being and now it has been made as one of the Indian Institutes of Technology).

ii. Roorkee was one of most important centres of the Defence Ministry Engineering Services.

iii. At the time of planning the Central Building Research Institute, the UP Government had also decided to locate their irrigation Research Station at Roorkee.

While commenting on the choice of the site for locating the Institute, Bhatnagar in his address on the occasion of its Foundation Laying Ceremony on February 10, 1951 said: "Several sites round about Roorkee were inspected and a piece of land measuring over 250 acres near the university estate was our first choice. This land belonged to the Ministry of Defence who regretted their inability to transfer it to the Council as it formed a part of its training ground. Later on with the assistance of the Government of Uttar Pradesh, a site near Roorkee Railway Station was acquired. The villagers to whom the land belonged, however, reported that the land allotted was the sole source of their livelihood and offered stiff resistance. Considering that the land was used for production of food grains, we allowed the farmers to continue their possession and released the land. At this stage, the University of Roorkee and its Vice Chancellor Prof. C. A. Hart again came to our assistance and offered to place a plot of land measuring ten acres for the building of this Institute at the disposal of the Council on long lease. This is the site on which this foundation stone is being laid today...."

The Central Building Research Institute, Roorkee, has been vested with the responsibility of generating, cultivating and promoting building science and technology in the service of the country. The main objective of the institute is to carry out applied and basic research in all areas of building science to solve problems confronting the country in: Shelter planning; Building materials; Structures and Foundations; Disaster mitigation including Fire Engineering. Since its inception the Institute has been engaged in development of new

technologies for the promotion of building materials and systems to achieve economy, comfort, functional efficiency, speed, productivity in construction, environment preservation and energy conservation. The Institute disseminates its results of research far and wide for the good of community. It also transfers the developed technologies to the industry for further commercialization.

## 12. Central Salt Research Institute (later renamed as Central Salt and Marine Chemicals Research Institute)

In 1940, Bhatnagar established the Salt Research Committee to formulate research programme on the production and utilization of salt. In 1948, the Salt Research Committee was amalgamated with the Heavy Chemicals Committee under the Chairmanship of Dr. Mata Prasad. A research station and a model Salt Farm was established by the Government of India at Wadala (Bombay). The Research Station established under the Salt Commissioner in 1949 was placed under the supervision of the Heavy Chemicals Committee. In September 1951, Shri C.C. Desai, then Secretary of the Ministry of Works, Production and Supply, put forward the idea that a Central Salt Research Institute be established under the CSIR with the objective of carrying out research on marine salt and also salt from inland lakes and sub-soil brine. The Ministry of Works, Production and Supply suggested that the proposed institute should be located in Saurashtra. The financial support for setting up institute would come from the Salt Development Cess. At this juncture, the Government of Saurastra offered to make available any suitable building for housing the institute. And in case not suitable building could be found, then the Government of Saurashtra would bear the expenditure for construction of a new building. Considering this proposal and also the suggestion made by the Ministry of Works, Production and Supply, the CSIR decided to set up the institute in Saurashtra. After making a survey, it was decided that Bhavnagar would be the location for the institute. For housing the Institute at Bhavnagar, the Government of Saurashtra

made available to the CSIR, a magnificent building, Raj Hotel and two Bungalows. The Government of Saurashtra also made available 125 acres of land for the experimental salt farm. The institute was opened in 1954 and its first Director was Dr. Mata Prasad. The main objective envisioned for the Institute was to work out methods for improving the quality of salt and to increase salt production for domestic as well as industrial uses.

## 13. Central Electronics Engineering Research Institute

The Foundation Stone for the CEERI was laid on September 21, 1953. It was located at Pilani in Rajasthan. On the occasion of the foundation stone laying ceremony of the Institute on September 09, 1953 Pandit Jawaharlal Nehru Said: "The modern world is a world of science, whatever sphere of life we examine, we find that we cannot live without the help of science. That is why we have determined that our country should progress in science. What is the object of establishing an Electronic Institute? The ultimate object is the welfare of the people of India." CEERI was established in 1953, for advanced Research and Development (R&D) in the field of Electronics. Since its inception it has been working for the growth of electronics in the country. It undertakes R&D in the following three major areas: Electronics Systems; Microwave Tubes; and Semiconductor Devices. In the area of microwave tubes the major focus is on communication tubes and industrial tubes. In the area of semiconductor devices, projects are being actively pursued on IC design, power devices, device processing, microwave devices, hybrid microcuits, opto-electronic devices and semi-conductor materials. R&D work in the area of electronics systems is focussed on digital systems, agri-electronics, speech technology, industrial electronics, instrumentation systems and communication engineering.

## 14. National Botanical Research Institute

NBRI is the premier national plant research centre in India.

Originally it was known as Sikander Bagh, the legendary royal garden of the erstwhile Oudh kings who ruled the region during the 19th century before it was taken over by the British in 1857. Later the State Government of Uttar Pradesh set up it as the National Botanic Garden.

The CSIR took over National Botanic Garden in 1953 and expanded the scope of the institute into multidiciplinary plant research centre and renamed it as the National Botanical Research Institute in 1978. The NBRI focuses on both basic and applied aspects of plant sciences for the conservation and sustainable utilization of plant genetic resources for human welfare and sustainable development. The Institute caters to the need of almost every aspect of plant research in South Asian region in general and India in particular.

The major R&D programmes of the institute are:

1. Biodiversity research by inventoring, monitoring, assessment, conservation and sustainable utilization of plant genetic resource of India with special focus on medicinal, aromatic, dye and gum yielding plants.
2. Bioprospecting for search of commercially valuable genes, biodynamic compounds and development of scientifically validated, value-added and standardized novel plant products - herbal drugs, pharmaceuticals, nutraceuticals and cosmaceuticals.
3. Biomass biology including biopesticides, biofuels and petroleum alternatives, and environmental sciences including phytoremediation and batement of terrestrial and aquatic pollution including studies on greenhouse gas emission.
4. Bioinformatics by developng computerized/electronic databases on Indian plants with special focus on medicinal, aromatic, dyes, gum and tannin yielding plants and rare & threatened plants of botanic gardens and implementing applications of IT in plant science research & develop bio-information products.

5. Biotechnology (biotech processes/products) including trans-disciplinary studies on molecular biology and genetic engineering for development of transgenic plants.
6. Genetics, Plant Breeding and Agrotechnology : Selection and genetic enhancement for development of new promising varieties of economically important non-crop plants.
7. Enriching national herbarium and maintaing over 1,25,000 national reference collections and making them accessible to a large number of users.
8. Developing and maintaining a National Botanic Garden of over 7,000 species/cultivars with theme gardens for eco-education including special facilities for the physically challenged and visually impaired persons.

The institute offers consultancy and technology on various aspects of plant sciences including information technology.

Today there are 37 laboratories under the CSIR. In addition there are two other specialized Institutes—National Institute of Science, Technology and Development Studies (NISTADS) and National Institute of Science Communication and Information Research (NISCAIR). Over the years some of the institutes have been renamed. The list of the CSIR laboratories is given in Annexure-II.

7

# THE EDUCATIONIST

*"While I would like to see that rigorous standards are imposed in selecting students for university education, I do not think we have an over-abundance of graduates in this vast country. The cry for closing down universities may at best be regarded as an emotional outburst and cannot be considered practical or desirable. It is true, we should raise the quality of university training. We need more and better teachers, more equipment and more books. If our means do not permit us to train vast numbers of students, we shall rather reduce the number but not sacrifice the quality."*

**—Shanti Swarup Bhatnagar**

BHATNAGAR'S contribution in the field of education is quite significant. He was an excellent teacher and an accomplished researcher. He taught for 20 years in the universities. He inspired a large number of students and many of them in later life occupied important positions and spread the ideals of their teacher. Bhatnagar's views on education are as relevant as they were in his times.

Bhatnagar was the first Chairman of the University Grants Commission. As the first Chairman of the University Grants Commission, he visualized its role as the custodian of the autonomy of the unviersities. Bhatnagar in his address at the 28th Convocation of the Andhra University on December 11, 1954 said: "None of the freedoms to which the modern world aspires seems to be more important than the freedom to learn, to speak and to write. Well used, this freedom of the universities would foster original thinking and independent action. It would help in developing honest opinions

unbiased by personal interests or party affiliations. It is because of this that all universities wish to be autonomous on essential matters... The University Grants Commission is your servant and guardian against all attacks on your autonomy."

Bhatnagar had envisioned different roles for the universities and the central laboratories. But then there could be some overlapping as well. He believed that the universities must be provided with enough resources to play an effective role in the field of fundamental research. He said: "Generally speaking, universities are concerned mainly with fundamental research while the activities of national laboratories lie essentially in the domain of applied research, though these laboratories are not preclude from taking up investigations of the fundamental character. In appraising the role of universities we have to bear in mind the difficulties facing them in shortage of equipment, personnel and finance. The Scientific Manpower Committee, over whose deliberations I had the honour to preside recognised these difficulties and recommended to the Government that substantial grants should be made to universities to purchase of scientific equipment, appointment of scholars etc. Large sums of money have been spent to meet their requirements."

Bhatnagar felt that it was the duty of the scientist to make the common man aware of their work. He said: "The most distinguished scientists are those who are able to convey, to the layman the results of their findings in neat and understandable languagae. This faculty is best developed by a study of humanities. It is evident that an engineer who is not conversant with industrial psychology or who does not look after the welfare of the labour under his charge will not be able to go a long way, however eminent he may be in his own special field. Considerations of this nature have led to the inclusion of humanities as a part of our general technical education programme."

Bhatnagar emphasised the need to instil a spirit of adventure among the students. This he thought was more important because India was under foreign rule and which discouraged the natives

of the country to be adventurous. Students should explore and be ready to tread unconventional paths. Bhatnagar said: "In a country which has been under foreign rule, it is of greatest importance that the spirit of daring and adventure should be cultivated rather than suppressed. This suppression of the spirit of adventure is visible in many phases of student life. Flocking of students in universities for a degree is one example of it. Over-crowding of class in certain subjects which helped prospects in the past for some kind of employment is another example. Lack of desire to explore not commonly traversed fields and professions is ultimately to be traced to the timidity which our students have acquired under an alien rule. As a result of this, we notice that requests from university students for taking our voyages of exploration or expeditions to conquer high peaks of mountains, or to achieve swimming records or to cover on foot or bicycle the whole globe are comparatively few and our students suffer terribly in comparison with students of other countries. It is a happy augury that State and Union Governments are thinking of starting a school of mountaineering in India which will be named after Tensing, the Indian conqueror of Mt. Everest."

Bhatnagar believed that the universities should also take part in applied or industrial research. In his Presidential address to the annual meeting of the Lahore Branch of the Indian Chemical Society on February 24, 1939, Bhatnagar said: "I am all for the development of research associations but the universities should not and cannot be divorced from industrial research activities. First rate industrial research can only come from one who is a first-rate research worker. Problems of a routine character should not interest a great worker, but new uses for raw materials, now processes, new machines, and new methods of investigation require the highest intellect. Science and industry go hand in hand and any attempt to divorce them will lead to an unsatisfactory and unhappy state of affairs. Fundamental research helps industries but problems of fundamental interest are also suggested by industry."

# 8

# HONOURS

*"The sensitive mind of the scientist is deeply susceptible to kindness and even a small recognition of his work is a great incentive to further effort but honours are not what he lives for. Of belated honours he should think as did the great novelist, Thackaray. 'When I was a lad, I wanted toffee, but I hadn't a shilling. Now I'm a man. I have the shilling, but I don't want toffee."*

**—Shanti Swarup Bhatnagar**

In 1936, the British Government conferred on Bhatnagar the Order of the British Empire (OBE) for his excellent work in pure and applied chemistry. In 1943, the Society of Chemical Industry, London, elected him an Honorary member and later Vice President. The testimony states: "That on Monday, January fourth in the year 1943 at the Royal Institution, London, the rare distinction of HONORARY MEMBERSHIP OF THE SOCIETY OF CHEMICAL INDUSTRY was by the order of the Council and in the presence of large gathering of Members CONFERRED BY THE PRESIDENT Dr WILLIAM CULLEN ON SIR SHANTI SWARUP BHATNAGAR, a Doctor of Science of the University of London and Director of the Department of Scientific and Industrial research of India in commemoration os his life-long activities as a Research worker in the realm of pure and applied chemistry which branches of science he has enriched by his pioneer work. The Council in deciding to bestow this honour selected with great care one whom they considered worthy, for in addition to his manifold contributions to our knowledge, he has through his selfless devotion to his scientific and academic duties

done everything possible to maintain the status and dignity of the chemical profession."

In 1943 Bhatnagar was also elected Fellow of the Royal Society of London. Bhatnagar's old research supervisor F.G.Donnan, who proposed Bhatnagar's name, was elated on his election. Donnan wrote: "All luck and happiness to the new F.R.S. So far as I knew, you are the first Indian chemist to be elected. Needless to say, I am very proud that this honour and a well-deserved one, comes to my old friend and former research student, S.S.B! 'They' must now proceed to make you a K.C.S.I. However, I know what a modest man you are and that you value the F.R.S. above, other honours, for it is no more 'official' honour but signified a man who has distinguished himself 'by the advancement of Natural knowledge'—as you have done. I can assure you that your election to the Royal Society has given me more pleasure and happiness than anything that has happened for years. I hope you will be granted many happy and successful years in which to enjoy the distinguished position in great world of science which you have won for yourself by your devoted labours in the pursuit of new knowledge.

Sooner or later, a new Fellow has to appear at a meeting of the Society and sign the famous charter Book. This is the actual original book, first signed by King Charles II in 1662. I hope that great occasion will come sooner than later. Whenever it occurs, there will be great rejoicing amongst your friends in England and I hope I shall be there."

Bhatnagar did not sign the 'famous Charter Book' in London. And so the wish of Donnan to be present on the signing ceremony of his dear student was not fulfilled. Prof. A.V. Hill, then Secretary of the Royal Society visited India in November 1943. The purpose of his visit was to advise the Government of India on the organisation of scientific research in the country. Prof. Hill brought with him a parchment upon which he was authorized by the President of the Royal Society, then Sir Henry Dale, to take the signatures of

Bhatnagar and Homi Jehangir Bhabha, the two new elected Fellows of the Royal Society from India. This way the formality was completed for admitting Bhatnagar and Bhabha to the Royal Society. The signing ceremony took place at the inaugural session of the India Science Congress in 1944. The then Vice-Chancellor of the Delhi University Sir Maurice Gwyer requested the permission of the Viceroy of India then Viscount Wavell for allowing to perform the ceremony. "Sir, on behalf of the Reception Committee of the University of Delhi and of all those present today, I thank you for coming here of this historic occasion. I have the honour to request Your Excellency formally to open the congress; but first I will ask you to permit Professor Hill to exercise the powers which have been delegated to him by the President of the Royal Society and to perform a ceremony which is without precedent not only in India but also, I believe, in the history of the Royal Society itself."

The British journal of science, *Nature,* one of the most revered international science journals, wrote: "The election of Sir Shanti Swarup Bhatnagar to the fellowship of the Royal Society is a well-deserved recognition of his distinguished contributions to the advancement of Science. The event is indeed a signal one, for he is the first Indian chemist to receive this honour.

It is no exaggeration to say that a component and very important part of the great work which India is doing in the War is due to the successful labours of the Board and Council of Scientific and Industrial Research and it is a source of deep satisfaction that the Board's first director of research is an eminent Indian man of science and a Fellow of the Royal Society of London."

On the occasion of his election as Fellow of the Royal Society, Bhatnagar's science teacher at school wrote: "Your election to the Royal Society is a matter of special pride to me as I believe I am your first teacher who taught you sciences. From the very beginning I told you and the Headmaster of the school that you were going to make a mark in life. I could not say that you would become

a Fellow of the Royal Society, but I knew you would rise to great heights. My joy is further heightened by the realization that I not only taught you but also Lajwanti who is your wife and is well known as Lady Bhatnagar."

Bhatnagar received honorary degrees from a large number of Universities including Oxford, Punjab, Delhi, Banaras, Lucknow, Allahabad, Patna, Agra and Sagar. He was the President of the Indian Chemical Society, National Institute of Sciences of India and Indian Science Congress. He was a member of large number of Indian and British Societies and Academies.

Bhatnagar represented India on many occasions in foreign countries. He was delegate to the British Association in 1923 and in 1932 when he attended the Michael Faraday Centenary celebrations. Bhatnagar attended the Empire Universities Congress at Edinburgh (1931) and at Cambridge (1936) as a member of the Indian delegation. In 1946 Bhatnagar was the leader of the official delegation of the Empire Scientific Conference. He was the Member of the Atomic Energy Commission which visited Great Britain in 1948. Bhatnagar also attended the United Nation's Scientific Conference on Utilisation and Conservation of Natural Resources held in New York in 1948.

Bhatnagar's sixtieth birth day was celebrated with great deal of popular enthusiasm and high tributes were paid to him by Pt. Jawaharlal Nehru and Sir Alfred Egerton among others.

Bhatnagar was a Fellow of the National Institute of Sciences, India and served as its Vice-President and President. He was the first Indian to get elected as Member of the Society of Chemical Industry, London in 1943. He was President of the Indian Chemical Society.

Bhatnagar was President of the Chemistry Section, Indian Science Congress in 1928 and then again in Silver Jubilee Session in 1938. He also served as the General President of the Indian Science Congress.

**He was associated with a number of Advisory Bodies.**

- Member, Quinquineal Reviewing Committee (commonly known as Sir James Irvine Committee) appointed by H.E. the Viceroy for the Indian Institute of Science, Bangalore.
- President, Advisory Board, Indian Lac Cess Committee.
- Member, Governing Body, Indian Lac Cess Committee.
- Member, Publication Committee of the Imperial Council of Agricultural Research.
- Member, Committee set up to enquire into the deterioration of Elephanta Caves.
- Member, Standing Committee for Section of 1851 Royal Exhibition Scholarship for India.
- Member, Advisory Board of the Imperial Institute of Sugar Technology.
- Member, Joint Power Alcohol Committee, U.P and Bihar Governments.
- President, Chemical Sub-committee of the Joint Development Board, Punjab Government.
- Member, Central Advisory Board of Utilisation, Forest Research Institute, Dehradun.
- Member, Advisory Board, Imperial Council of Agricultural Research.
- Member, Industrial Research Utilisation Committee.
- Chairman, Plastics Committee, Board of Scientific and Industrial Research.
- Chairman, Vegetable Oils Committee, Board of Scientific and Industrial Research.
- Chairman, Distillation and other Chemical Plants Committee, Board of Scientific and Industrial Research.
- Chairman, Central Glass Research Committee, Board of Scientific and Industrial Research.

- Member, Heavy Chemicals Committee, Board of Scientific and Industrial Research
- Member, Fertilisers Committee, Board of Scientific and Industrial Research.
- Chairman, Oil Dressed Fabrics Committee of the Department of Supply, Government of India.
- Chairman, Committee appointed by the Defence Department to go into the question of the reorganization of the Inspectorate of General Stores Laboratories, Kanpur.
- Chairman, Committee set up by the Supply Department
- Honorary Visitor, Royal Institute of Science.
- Member of the Executive Council and Court of the Indian Institute of Science, Bangalore.
- Secretary, Scientific Consultative Committee
- Member-Secretary, Atomic Energy Commission, Govt. of India.
- Member, Railway Research Advisory Committee
- Member, Central Board of Geophysics.
- Member, Defence Science Policy of the Ministry of Defence.
- Member, Governing Board, Ahmedabad Textile Research Association Laboratories.
- Member of the Research Board of Rajasthan University.
- Member of the Executive Council of the Bose Institute, Calcutta.
- Chairman, Scientific Manpower Committee, Ministry of Education.
- Member, All India Council of Technical Education.
- Member, Selection Committee for the award of Post-graduate Fellowships offered by the National Research Council of Canada.

- Member, Advisory Committee for the Ferliser Project, Sindhri.
- Member, Committee to consider reorganization of the Mathematical Instruments Office, Ministry of Industry and Supply.
- Member, Fisheries Advisory Council, Ministry of Agriculture.
- Member, Advisory Board for Mineral Development
- Member, Civil Defence Committee, Ministry of Home Affairs.

Bhatnagar was awarded Honorary Doctorate degree by a number of Universities: Patna University (1944), Oxford University (1946), Allahabad University (1947), Delhi University (1948), Lucknow University (1949), Agra University (1949), Banaras Hindu University (1949), Punjab University (1949), and Sagar University (1949).

Bhatnagar was awarded *H.K. Sen Memorial Gold Medal* for distinguished research work in industrial chemistry (1945); *J.K. Mukherjee Gold Medal* awarded by the Indian Association for the Cultivation of Sciences for eminence in science (1945); *Madathu Reddy National Prize* for best work in chemistry from India (1946).

The Governing Body of the CSIR at its meeting held on November 03, 1962 decided that four prize of Rs. 10000/- each be given annually as *S.S. Bhatnagar Memorial Award* for Scientific research in the disciplines of Physical, Chemical, Biological and Medical sciences or engineering. The Shanti Swarup Bhatnagar Awards are now widely recognised as the most prestigious scientific awards of the country. These prizes are given to those who are 45 or less in age, and practically every awardee has stayed back in the country. The award has therefore has proved to be a powerful incentive for retaining some of our most talented scientists.

In 1994, the Government of India brought out a Postal Stamp at the birth centenary of Bhatnagar.

# 9

# THE END AND HIS LEGACY

*"He (Bhatnagar) was a visionary extraordinary who saw the need for a strong scientific infrastructure for the independent India. He pioneered the concept of organised' research at a time when the scientific establishment of the day scorned him for this effort. He created institutions which became the 'cradle' for science in India and which have stood the test of time of both relevance and need."*

**—S. Sivaram**

BHATNAGAR did not live long enough to think in retrospect over his deeds. He died on January 01, 1955 after a massive heart attack. Perhaps his extreme hard work was one of the reasons of his early death. After his death Maulana Abul Kalam Azad, the well-known Congress leader and then a minister in the Union Cabinet, said: "I often felt that the effect of such hard work might fell upon his health. In spite of my repeated requests, he would not, however, refrain from his hard work. Last year we sent him out in connection with the work of scientific research. I extended his deputation by two weeks and asked him to take complete rest for a fortnight in Switzerland. I have no doubt that this passion for work reduced the duration of his life and he could not live without work." At the time of his death he was occupied with so many important activities. We are told the he had expressed his desire to live in a rural area after his retirement where he thought to take up farming. When free from farming activities he would devote to chemistry and poetry in Urdu. He even thought that his wife would devote to gardening. We must not forget that in his heart he was a romantic poet. So no wonder that his imaginations

took wings and visualised a scenario where he would be working in the fields and his wife would bring lunch for him carrying on her head as usually farm workers do in villages. But all these plans for a retired life did not materialise. His wife had died in 1946, about nine years before his death.

Bhatnagar has left an example of what one can achieve with hard work, dedication and concern for the society. When Bhatnagar was called upon to give shape to the industrial research he had no infrastructural support, he had to create it himself. Bhatnagar, through his efforts, wholeheartedly supported by Sir Arcot Ramaswamy Mudaliar, created the Council of Scientific and Industrial Research (CSIR), even before India attained independence. The Board of Scientific and Industrial Research (BSIR), the predecessor of the CSIR, started with meagre annual budget of Rs. 5 lakhs and a few small laboratories in Government Test House at Alipore. From this humble beginning it has now grown into one of the largest scientific organisations in the country. Even during his lifetime the CSIR had proved its utility towards the promotion of national welfare. Scientists working in the CSIR laboratories were invited to take leading parts in all activities promoting industry, supply, medicine, public health, agriculture, food, communications and so on. Today the CSIR has some 40 laboratories with a total scientific and technical staff strength of about 10000. From Rs. 5 lakhs, its annual budget has exceeded Rs. 1000 crores. The CSIR possess an outstanding research infrastructure and wealth of experience. The CSIR's advanced laboratories established in different parts of the country greatly contributed towards achieving self-reliance in many key areas. The CSIR has encouraged closer interaction between laboratories and industry. Jayant Vishnu Narlikar, one of the most well-known Indian scientists, considers that "progress towards transforming the Council for Scientific and Industrial Research (CSIR labs' orientation from workbench research to industry and the marketplace) since the late 1990s" as one of the ten achievements of Indian science in the twentieth century.

Bhatnagar's life was of a true "Karma Yogi". Bhatnagar had shown what an individual could do with a greater sense of devotion to duty and hard work. He urged the young ones to develop a sense of devotion to duty. He had told us to keep in mind that in the case of a nation the greatest asset is the people. Bhatnagar urged students to take part in the progressive march of the nation. While addressing the third Convocation of the Maharana Sayajirao University of Baroda (now Vadodara), Bhatnagar said: "I would like students of Indian universities to develop a greater sense of devotion to duty and hard work. 'The force, the mass of character, mind, heart, or soul, that a man can put into any work is the most important factor in that work'. In the case of a nation, 'the greatest asset is the spirit of its people and the greatest danger that can menace it is the break-down of that spirit, the will to work and the courage to work. A nation's welfare depends on its ability to master the world, on its power of work and on its power of thought.' We in this country are in the midst of a huge development programme and much has to be done in all spheres of national activity to effect progress. If our students take interest in the developments which are taking place and shoulder a part of the burden, they will be assisting in the progressive march of the nation." This is equally true today and it will be true in future. No nation can prosper if its youths are not participants in its development process.

Bhatnagar urged the young people to be adventurous. He believed that the suppression of spirit of adventure among the young people was detrimental to the progress of the nation. He particularly urged that education in schools, colleges and universities should not damp students' enthusiasm for daring and adventure rather it should inculcate and stimulate it. Bhatnagar was a great optimist. There is always hope for a better future. "There is no reason to believe that all that is best has already been achieved and that there is no future for winning fresh laurels for younger men." To support his point once he quoted an optimistic poet;

*"The best verse has not been rhymed yet;*
*The best house hasn't been planned;*
*Many majestic rivers aren't spanned;*
*Don't worry and fret, faint-hearted;*
*For the best jobs haven't been started;*
*The best work hasn't been done."*

This philosophy of optimism is much relevant today. Without a sense of optimism nothing can be achieved. Our younger generation should learn from Bhatnagar that one should have an abiding faith in future of our country and the fact that there is always scope for doing better and more glorious work.

Bhatnagar had an abiding faith in science. He worked and lived for furthering the cause of science and to make science useful to the society. He said: "There are hardly any new lands which India can hope to exploit. Science may discover new sources of wealth in land we hold and grow new materials in them. The only new lands on which we may have our eyes must lie in the domain of the mind and have to be created in the research laboratory. It is on these sources which will emerge from the national laboratories that we have to depend now and in the future for the means to maintain and raise our standard of living and to keep amongst the best nation of the world." So Bhatnagar talked about a knowledge society at a time when people were yet to appreciate its true significance.

Bhatnagar believed that it is the responsibility of scientists to take their findings to laymen. "The most distinguished scientists are those who are able to convey, to the layman the results of their findings in neat and understandable language", said Bhatnagar. This is very important today. In today's life every citizen of the country should develop a scientific awareness. And the scientists can and should play a meaningful role in this direction. Bhatnagar once said, "There is no force more unifying than Science and through Science we may yet realize One World." This spirit of Bhatnagar is his true legacy.

# LIFE SKETCH IN BRIEF

1894: Born in an educated family at Bhera, Punjab (Now in Pakistan) on February 21.

Bhatnagar's father died.

1901: Joined a private school called Maktab in Sikanderabad.

1908: Left Sikanderabad for Lahore to be admitted into the Dyal Single High School.

1911: Passed the Matriculation Examination and joined Dyal Singh College at Lahore. Published a letter to the editor in *The Leader* on how to make a substitute for carbon electrodes in a battery.

1913: Passed the Intermediate Examination of the Punjab University in the first division. Joined the Forman College

1915: Married Lajwanti, the elder daughter of Rai Shib Lala Raghunath Sahai, his father's classmate and friend, on 31st May.

1916: Obtained his Bachellor Degree

Appointed as Demonstrator

1919: Obtained his MSc

Sailed for the United States via England on 4th August

1920: Published his first research paper in the *Journal of the Chemical Society*, London and by 1921 he had published eight research papers.

1921: Awarded DSc degree of the London University.

Joined the Chemistry Department of the Banaras Hindu University in August. The Banaras Hindu University was founded by Pandit Madan Mohan Malaviya in 1916.

1923: Delegate to the British Association for the Advancement of Science, Liverpool.

1924: Joined the Punjab University as Professor of Physical Chemistry and Director of University Chemical Laboratories.

1927: Initiated studies in magneto-chemistry

1928: Invented (in collaboration with K N Mathur) the Magnetic Interference Balance (Later called as Bhatnagar-Mathur Magnetic Interference Balance).

Became the Sectional President, Chemistry Section, Indian Science Congress

1931: The Bhatnagar-Mathur Magnetic Interference Balance, manufactured by Messers Adam Hilger of Camden Town, London, was exhibited at the Royal Society soiree In London.

Delegate to the Faraday Centenary Celebrations.

1935: His book (jointly with K.N. Mathur), *Physical Principles and Application to Magneto-chemistry,* was published by Macmillan & Co.

1936: Conferred the O.B.E (Order of the British Empire)

Delegate to the Empire Universities Congress, Edinburgh

1938: His last research paper was published in *Current Science*.

1940: Took over as Director of Scientific and Industrial Research, Government of India.

1941: Was knighted in recognition of his work for the war effort

1943: The Society of Chemical Industry, London elected him an Honorary Member.

Elected Fellow of the Royal Society of London

1945: Presided over the Indian Science Congress held at Nagpur.

1946: His wife Lajwanti died on February 03.

1947: Appointed as Secretary to Ministry of Education and Educational Adviser to the Government of India.

1951: He became the first Secretary to the Ministry of Natural Resources and Scientific Research.

1953: Became the first Chairman of the University Grants Commission

1954: The Government of India conferred on him Padma Vibhushan, the Second highest Civilan Award.

1955: Died on 1st January.

# SUPPLEMENTARY NOTES

**Absorption**: The take up of gas by a solid or liquid, or the take up of a liquid by a solid. Absorption differs from adsorption in that the absorbed substance permeates the bulk of the absorbing substance.

**Adhesion**: Intermolecular forces which hold matter together, particularly closely contiguous surfaces of neighbouring media for example liquid in contact with a solid.

**Adsorption**: The taking up of one substance at the surface of another.

**Aliphatic compounds**: Organic compounds in which the carbon atoms are linked in a string (open chain)—they may be joined in straight chains, as in hexane ($C_6H_{14}$) or in branched chains, as in 2-methylpentance ($CH_3CH$-$(CH_3)CH_2CH_2CH_3$).

**Allotropy**: The property in which a chemical element can exist in more than one form (allotrope), each form differing in physical properties but having the same chemical properties. The allotropes of carbon are diamond and graphite.

**Alloys**: An alloy is a substance that is mixture of two or more metals, or of a metal with a non-metallic material, Such mixtures give a metal special qualities such as resistance to corrosion, greater hardness, or tensile strength. Bronze, brass, duralumin, German silver, gunmetal, and steel are examples of useful metals.

**Aromatic compounds**: Organic compounds in which some of the bonding electrons are delocalised that is shared among several atoms within the molecule and not localised in the vicinity of the atoms involved in bonding. They contain one or more rings and undergo chemical reactions that are characteristic of benzene.

**Arthur Holly Compton**: US physicist and Nobel Prize winner Arthur Holly Compton (1892-1926) was born in Wooster, Ohio. He studied at Princeton University and Cambridge and he held posts at Washington University in St Louis, and at Chicago University. Compton developed a theory to describe the interaction of X-rays with matter, based on Albert Einstein's concept that light consist of particles, or photons. He proved his theory by measuring the wavelength of X-ray scattered by a target. He shared the 1927 Nobel Prize for physics with Charles Wilson.

**Asutosh Mookerjee**: A well-known jurist of his time, Mookerjee (1864-1924) was regarded a great educationist. For twenty years he was a Judge of the Calcutta High Court. He was the living spirit in the field of higher education at the Calcutta University. As a Vice Chancellor of the University he established the University College of Science, where he inducted great stalwarts of Indian science like C.V. Raman, Meghnad Saha, Satyendranath Bose and Siser Kumar Mitra.

**Brahmo Samaj**: The *Brahmo Samaj* was founded by Raja Rammohun Roy in 1828. Originally it was called Brahmo Sabha—an assembly of all who believed in unity of God. After the death of the Raja, Devendranath Tagore infused new life into the Society. Devendranath formally joined the movement in 1843 but the spread of the organisation was largely due to Keshab Chandra Sen who joinded the movement in 1857. In 1865, the *Brahmo Samaj* was divided into two camps—the conservatives and the progressives. The latter camp was headed by Keshab Chandra Sen. Then again the marriage of Keshab Chandra's fourteen year old daughter with Maharaja of Cooch Bihar in March 1876 led to the second schism in the *Brahmo Samaj*. Keshab Chandra held moderate views about women's education and women's emancipation. He believed higher education, particularly university education, would not be suitable for women and unhindered mixing of men and women or the complete ban on the *purdah* system was fraught with grave danger to society. Those who differed with

the great leader formed a different organisation known as *Sadharan Brohmo Samaj*.

**Calorimery**: The measurement of thermal constants such as specific heat, latent heat or calorific value. Such measurements usually necessitate the determination of a quantity of heat, by observing the rise of temperature it produces in a known quantity of water or other liquid.

**Carbonisation**: The conversion of fossil organic material to a residue of carbon. Plant material is often preserved in this way.

**Chandrasekhara Venkata Raman**: The first Indian to receive a Nobel Prize in Science (1930), Chandrasekhar Venkata Raman (1888-1970) made many major discoveries in acoustics, ultrasonic, optics, magnetism and crystal physics. His celebrated discovery, the Raman Effect, experimentally demonstrated that light quanta and molecules do exchange energy which manifests itself as a change in the colour of the scattered light. Lord Rutherford while commenting on Raman's scientific achievements, said: "Sir Venkata Raman is one of the leading authorities in optics, in particular on the phenomenon of the scattering of light. In this connection, about three years ago, he discovered that the light's colour could be changed by scattering. This had been predicted some time before, but in spite of search the change had not been found. The 'Raman Effect' must rank among the best three or four discoveries in experimental physics in the last decade; it has proved and will prove to be an instrument of great power in the study of the theory of solids..." Raman established a vibrant and excellent school of physics in India. He established the Indian Academy of Sciences, Bangalore (1934) and the Raman Research Institute, Bangalore (1948).

**Cohesion**: The attraction forces between molecules of a liquid which enables drops and thin films to be formed. In gases the molecules are too far apart for cohesion to be appreciable.

**Colligative properties**: Those properties of solutions which depend only on the concentration of dissolved particles, ions and molecules,

and not on their nature. They included depression of freezing point, elevation of boiling point and osmotic pressure.

**Colloid**: Systems in which there are two or more phases, with one (the dispersed phase) distributed in the other (the continuous phase) and where the size of the dispersed particles (1-1,000 nenometres across) is less than that of particles in suspension but greater than that of molecules in true solution.

**Daulat Singh Kothari**: A student of Meghnad Saha, D S Kothari (1906-1993) is regarded as the architect of defence science in India. He was a multi-faced personality— an outstanding teacher, a great educationist, a renowned physicist and a highly successful leader and organiser. His work on pressure ionisation was highly acclaimed. He played an important role in the development of many organisations, notable among them are the University Grants Commission and the National Council of Education Research and Training.

**Electrolyte**: A chemical compound that separates into ions in a solution or when molten and is able to conduct electricity.

**Emulsification**: The process of dispersing something in an emulsion, or converting two or more liquids into an emulsion.

**Emulsifying agent**: A substance whose presence in small quantities stabilizes an emulsion is called an emulsifying agent or emusifier. Soaps and detergents are most common examples of emulsifying agents.

**Emulsions**: Colloids in which the dispersed and continuous phases are two immiscible liquids. Emulsions can be oil in water like mayonnaise or water in oil like margarine. Since they tend to be unstable, an emulsifying agent to stabilize the droplets in the disperse phase is needed.

**Fatty acids**: A group of saturated and unsaturated monobasic aliphatic carboxylic acids. The lower members of the group are liquids with pungent odour and corrosive action and they are soluble in water. The higher members from C 10 onwards are mainly solids and are insoluble in water.

**Jnan Chandra Ghosh**: A contemporary of Meghnad Saha and Satyendranath Bose, J.C. Ghosh (1893-1959) is remembered for his fundamental contributions to the theory of strong electrolytes. Great scientists like Walther Nernst, Max Planck, Sir William Bragg and G.N. Lewis were highly impressed by his work. He made important contribution to the promotion of education, science and technology in India. He served as Vice Chancellor of the Calcutta University. He succeeded C.V. Raman as the Director of the Indian Institute of Science, Bangalore in 1939.

**Norah Richards**: An accomplished dramatist, Norah Richards *nee* Hutman (1876-1971) was born in Ireland. She studied in Belgium, Oxford and Sydney. She came to India in 1908, when her husband Philip Earnest Richards, an English teacher and a Unitarian Christain took up the job of an English teacher at Dyal Singh College in Lahore.

**Homi Jehangir Bhabha**: The founder of the Tata Institute of Fundamental Research, at Mumbai, Homi Jehangir Bhabha (1909-1966) shaped the India's atomic energy programme. Among his important scientific contributions was the derivation of the correct expression for the probability of scattering positrons by electrons, a process now known as Bhabha scattering. His classic paper on cosmic-ray showers (1937) described how primary cosmic rays from space interact with upper atmosphere to produce the particles observed at ground level. This paper also demonstrated the existence of muons, a type of fast, unstable cosmic ray particles.

**Magnetic susceptibility**: The amount by which the relative permeability of a medium differs from unity, positive for a paramagnetic medium, but negative for a diamagnetic one.

**Magneto-chemistry**: The study of the relation of magnetic properties to chemical structure, particularly, extent of para-magnetism in transition metal compounds may be related to the type of ligand bonded to the metal.

**Meghnad Saha**: The theory of thermal ionisation proposed by MN Saha (1893-1956), which explained the origin of stellar spectra, was one of India's most important contributions to world science during the 20th century. Arthur Stanely Eddingtion (1882-1944), while writing on stars in the *Encyclopaedia Britannica*, desribed Saha's theory of thermal ionisation as the twelfth most important landmark in the history of astronomy since the first variable star (Mira Ceti) discovered by David Fabricius (1564-1617) in 1596. Saha was a great institution builder. Among the institutions that he built were: National Academy of Sciences, India at Allahabad; Indian Physical Society, Kolkata; National Institute of Sciences of India (which was later renamed Indian National Science Academy), New Delhi; Indian Science News Association, Kolkata and Saha Institute of Nuclear Physics, Kolkata.

**Micelles**: Colloidal aggregates of molecules formed in solution, especially soaps in water. Particles are often spherical, with hydrophobic chains in the centre surrounded by hydrophilic groups.

**Mineral**: A naturally occurring substance of more or less definite chemical composition and physical properties.

**Mirza Ghalib**: Of Seljuk, Turkish stock, Mirza Ghalib (1797-1869) was proud of his heritage. Ghalib's grandfather came to India from Transoxiana sometime between 1759 and 1760. Ghalib is one of the greatest poets of India. His true greatness was universally recognised only after his death.

**Pandit Madan Mohan Malaviya**: The founder of the Banaras Hindu University, Malaviya (1861-1946), played a leading part in India's freedom struggle. In 1914, he became the President of the Indian National Congress. He attended the Indian Round Table Conference in London in 1931.

**Petrography**: Systematic description of rocks, based on observations in the field, on hand specimens, and on thin microscopic actions.

**Phototropy**: The property possessed by some substances of changing colour according to the wavelength of the incident light. It also means the reversible loss of colour in a dyestuff when illuminated at a definite wavelength.

**Physical Chemistry**: A branch of chemistry that is concerned with the studies of physical and thermodynamic properties of substances in relation to their structures and chemical reactions.

**Polarity**: A permanent property of a molecule, which has an unsymmetrical electron distribution. Chemical compounds with polarity are called polar compounds. All the heteronuclear diatomic molecules have polar character.

**Prafulla Chandra Ray**: A chemist of international fame, he was popularly known as Acharya Prafulla Chandra Ray (1861-1944). He was a pioneer in setting up chemical and pharmaceutical industries in Bengal. His many-sided interests made him an ardent educationist, a selfless patriot and a devoted social worker. The first Prime Minister of India Jawaharlal Nehru described Acharya Ray in the following words: "Acharya Ray was one of the giants of the old and, more particularly, he was a shining light in the field of science. His frail figure, his ardent patriotism, his scholarship and his simplicity impressed me greatly in my youth..."

**Priyadaranjan Ray**: A Student of Prafulla Chandra Ray, P. Ray is a doyen of inorganic chemists in India. His researches covered various aspects of co-ordination chemistry, magneto-chemistry and microchemistry. He was a passionate teacher. Ray was deeply interested in the history of science. He believed that "History of science constitutes an integral part of human civilisation or of the true annals of the Earth; and as knowledge and wisdom grow only on the accumulated interests of the past, it forms an essential element in the study of science itself."

**Pyrometry**: The measurement of high thermal parameters.

**Ore**: A term applied to any metalliferous mineral from which the metal may be profitably extracted. It is extended to non-metals and also minerals which are potentially valuable.

**Oxidation**: The addition of oxygen to a compound. More generally, any chemical reaction that involves loss of electron is called oxidation. An oxidation is always accompanied by reduction.

**Photochemistry**: A branch of chemistry that deals with the effect of radiation, particularly of visible and ultraviolet light on chemical reactions and of the emission of radiation by chemical reactions.

**Raja Rammohun Roy**: A social reformer and statesman, Raja Rammohun Roy (1774-1833) was one of the key figures of modern Indian culture—a social and religious reformer, an educationist and politician. He founded the *Brahmo Samaj* in 1828. In 1830, he went to Englnad. The Mughal Emperor, Akbar II, appointed him his official envoy (conferring on him the title "Raja") to defend his financial interests before the British crown. He published various works in Persian, Arabic and Sanskrit with the aim of idolatry. He successfully agitated against the evil custom of *Suttee*. He issued an English abridgement of the *Vedanta*, which provided a digest of the Veda.

**Refractories**: Materials used in lining furnaces etc. They must resist high temperatures, changes of temperatures, the action of molten metals and slags and hot gases carrying solid particles.

**Rheology**: A branch of physics dealing with the way matter flows and changes shape.

**Ruchi Ram Sahni**: A man of independent thinking and progressive ideas, Ruchi Ram Sahni (1863-1948) was a multi-faceted personality. He was a scientist, an innovator, an enthusiastic educationist, a fierce patriot and a devoted social worker. He started his career as Second Assistant Reporter to the Government of India in the Meteorological Department in 1885 and later joined the Government College, Lahore as Assistant Professor of Chemistry and Physics and from where he retired as senior

professor in 1918. He has worked with Ernest Rutherford. One of his major achievements was the creation of scientific awareness amongst the common people of the State of Punjab in undivided India. Ruchi Ram Sahni took keen interest in shaping the scientific career of Bhatnagar.

**Solid solution**: A crystalline substance such as glass or an alloy in which certain atoms or molecules have been replaced by others without changing its structure.

**Surface tension**: The property of liquids that gives their surfaces a slightly elastic quality and enables them to form into separate drops. Because of this property the surface of a liquid behaves as if it was covered with a elastic skin and this is why a needle can float on water.

**Tej Bhadur Sapru**: One of the greatest constitutional lawyers of his time, Tej Bahadur Sapru (1875-1949) joined the moderate wing of the Indian National Congress and contributed articles to the *Leader*, a moderate newspaper. He served in the Untied Provinces legislative council from 1913 to 1916 and in the imperial legislative council from 1916 to 1920. He was the law member of the Executive Council (1920-23) of Viceroy Lord Reading. He attended the Indian Round Table Conference (1930-31), and was chiefly responsible for the Gandhi-Irwin Pact, by which Mahatma Gandhi, as the only representative of the Indian National Congress, was to be permitted to take part in the second session of the Conference.

**T.R. Seshadri**: A life-long adherent to the ideals of the Ramakrishna Mission, Tiruvenkata Rajendra Seshadri (1900-1975) was a chemist of international fame. He made the Department of Chemistry of the Delhi University as one of the most active centres in the country for research on the chemistry of natural products. His major contributions have been in the area of oxygen heterocyclics. The celebrated organic chemist Robert Robinsion commenting on his contributions said: "His original researches have indeed given him worldwide recognition and he is unsurpassed in the experimental

survey of the groups of natural products on which he has concentrated his attention."

**Vikram Ambalal Sarbhai**: The architect of India's space programme, Vikram Ambalal Sarabhai (1919-1971) was a rare combination of an innovative scientist, a progressive industrialist, a humanist and a visionary. Sarabhai worked with C.V. Ramn in the Indian Institute of Science, Bangalore. He made important contributions to the field of cosmic ray physics. In 1947, he established the Physical Research Laboratory at Ahmedabad, which became cradle of India's space programme. Besides laying the foundation of India's space programme, Sarabhai also played an important role in the development of India's atomic energy programme. He built a number of institutions in diverse areas. Sarabhai took keen interest in developing and encouraging scientific temperament in the young. He established a Community Science Centre at Ahmedabad under the auspices of Nehru Foundation for Development.

**X-rays**: A form of high-energy, electromagnetic radiation, X-rays have a wavelength between 0.01 and 10 nanometres, which is between gamma rays and ultraviolet light. X-rays can penetrate solids and ionise gases.

# ANNEXURE I

## Some of the processes completed in the Laboratories of the Director, Scientific and Industrial Research

1. Development of high tension ignition cable testing device for fuel use.
2. Manufacture of slushing varnishes for metal tanks for petrol storage.
3. Patching cement for repairing rubber and synthetic rubber tanks
4. Manufacture of slushing varnishes for rubber, synthetic rubber, and laminated tanks for carrying petrol in aircraft.
5. Manufacture of petrol pump diaphragms, proof against petrol, alcohol, and their mixtures.
6. Nimbidin, nimbidin emulsion and nimbidin gargle.
7. Development of petrol tank sealing composition.
8. Manufacture of smoke candles and distress signals for use in land and aerial operations,
9. Manufacture of non-inflammable water resistant cloth.
10. Manufacture of furfurol
11. Manufacture of substitute hairlock.
12. Manufacture of collapsible tubes.
13. Manufacture of lubricants from vegetable oils and vegetable oil, mineral oil bends.
14. Manufacture of carbon electrodes for dry cells, arc lamps, and arc welding.
15. Reclamation and use of Perspex.

16. Preparation of tin lining compound.
17. Improving hot food containers.
18. Antigas cloth.
19. Vegetable oil as fuels and lubricants.
20. Manufacture of laminated paper boards.
21. Manufacture of air foam solution
22. Manufacture of bhilawan stoving enamel and allied products.
23. Manufacture of luminous paints and pigments
24. Manufacture for substitute for glass
25. Manufacture of silver and glossy transparent paper.
26. Manufacture of solid fuel.
27. Manufacture of oil silks.
28. Manufacture of jute boards.
29. Water proof painting for indianite slabs.
30. Cork substitutes.
31. Sulphur from Baluchistan.
32. Manufacture of identity discs.
33. Manganese ores for dry cell manufacture,
34. Manufacture of barium chloride.
35. Manufacture of indigenous moulding powder S-HP.
36. Titanium dioxide from bauxite red mud and sludge.
37. Zinc salts from waste zinc slime.
38. Welding fluxes.
39. Pyrethrum cream.
40. Clay pigeons.

# ANNEXURE II

## Laboratories of the Council of Scientific and Industrial Research

| | | |
|---|---|---|
| 1. | Central Fuel Research Institute (CFRI) | Dhanbad |
| 2. | Central Building Research Institute (CBRI) | Roorkee |
| 3. | Central Leather Research Institute (CLRI) | Chennai |
| 4. | Central Road Research Institute (CRRI) | New Delhi |
| 5. | Central Food Technological Research Institute (CFTRI) | Mysore |
| 6. | Central Institute of Medicinal and Aromatic Plants (CIMAP) | Lucknow |
| 7. | Central Glass and Ceramic Research Institute (CGCRI) | Kolkata |
| 8. | Central Drug Research Institute (CDRI) | Lucknow |
| 9. | Central Electrochemical Research Institute (CERI) | Karaikudi |
| 10. | Central Electronics Engineering Research Institute (CEERI) | Pilani |
| 11. | Central Salt and Marine Chemicals Research Institute (CSMRI) | Bhabnagar |
| 12. | Central Mining Research Institute (CMRI) | Dhanbad |
| 13. | Central Mechanical Engineering Research Institute (CMERI) | Durgapur |
| 14. | Central Scientific Instruments Organisation (CSIO) | Chandigarh |
| 15. | Centre for Cellular and Molecular Biology (CCMB) | Hyderabad |
| 16. | CSIR Centre for Mathematical Modelling and Computer Simulation (C-MMACS) | Bangalore |

| | | |
|---|---|---|
| 17. | Indian Institute of Chemical Technology (IICT) | Hyderabad |
| 18. | Indian Institute of Chemical Biology (IICB) | Kolkata |
| 19. | Indian Institute of Petroleum (IIP) | Dehradun |
| 20. | Industrial Toxicological Research Centre (ITRC) | Lucknow |
| 21. | Institute of Genomics and Integrative Biology | Delhi |
| 22. | Institute of Himalayan Bioresource Technology (IHBT) | Palampur |
| 23. | Institute of Microbial Technology (IMTECH) | Chandigarh |
| 24. | National Chemical Laboratory (NCL) | Pune |
| 25. | National Botanical Research Institute (NBRI) | Lucknow |
| 26. | National Environmental Engineering Research Institute (NEERI) | Nagpur |
| 27. | National Institute of Science Communication and Information Resources (NISCAIR) | New Delhi |
| 28. | National Aerospace Laboratories (NAL) | Bangalore |
| 29. | National Metallurgical Laboratory (NML) | Jamshedpur |
| 30. | National Physical Laboratory (NPL) | New Delhi |
| 31. | National Geophysical Research Institute (NGRI) | Hyderabad |
| 32. | National Institute of Oceanography (NIO) | Goa |
| 33. | National Institute of Science, Technology and Development Studies (NISTADS) | New Delhi |
| 34. | Regional Research Laboratory (RRL) | Bhopal |
| 35. | Regional Research Laboratory (RRL) | Jammu |
| 36. | Regional Research Laboratory (RRL) | Bhubaneswar |
| 37. | Regional Research Laboratory (RRL) | Thiruvananthapuram |
| 38. | Regional Research Laboratory (RRL) | Jorhat |
| 39. | Structural Engineering Research Centre (SERC) | Chennai |

# ANNEXURE III

## Bhatnagar's Scientific Papers, Articles and Addresses*

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Whoever came in contact with him was touched by his intellect, diligence, honesty and above all, inherent simplicity.

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